TEXAS A&M UNIVERSITY
DEPARTMENT OF CHEMISTRY
COLLEGE STATION, TEXAS 77843-3255

June 20, 1989

Dr. David Thompson
Manager, New Technology
Johnson Matthey Technology Center
Blount's Court
Sonning Common
Reading RG4 9NH
UNITED KINGDOM

Dear Dr. Thompson:

Many thanks for coming to see us. It was an enjoyable visit for us.

I think one of the roles Johnson-Matthey can play, apart from being so good as to lend us palladium and organize analyses for Fleischmann and Pons, is to act as an evaluating center for the results which are coming in from all over the world on this subject.

I think it less likely that a Laboratory heavily funded for hot fusion work is going to be able to see cold fusion. The investigators literally don't see it, for the phenomena are inconsistent and ellusive, and it is easy to gloss over the occasional occurrence.

At the Santa Fe meeting, one of the people from Oak Ridge asked me to come to a separate room, shyly removed some documents from his briefcase, and said, "My boss will kill me if he thinks I'm showing you these things. You see, they're positive."

This shows how important it is to look towards parts of the world which are influenced less by the local negative and restrictive environment, - where everyone is afraid it will reduce their funding, -and look to countries where people have got less to lose.

I find white Americans even more xenophobic than the British! It's difficult to get American scientists to believe that results done outside the U.S., Japan, Germany and Great Britain are reliable. Their image of the rest of the world is that they're backward, and that science and engineering are done in the countries I've named.

Well, my list of Cold Fusion workers follows. It's in two parts. The first is from people I know. The rest is from people I have heard about. You'll probably find that when you have investigated it, my list is very incomplete.

Heat

The best work is with Mackubre at Stanford Research Institute. He got rid of the difficulty of recombination by using a deuterium fuel cell anode. Incidentally, there is a Group from DOE going around. However, it has only three electrochemists (electroanalytical ones at that) out of around 20 members and its clear that it had made up its mind NO PHEMONENA EXISTS before within it.

However, there are some questions which remain about our tritium work: Why did three electrodes out of eleven not give tritium? Further, was it so that the electrodes which gave tritium gave no heat? We do not know. We do know, however, that some electrodes which give heat do not give tritium in the solution.

Another group which reports tritium are Schoesser and Wellingford. These persons are, as it were, "sleepers" in the game. Schoesser is a retired professor of nuclear engineering. Wellingford is a younger professor. Two chaps working away quietly in their spare time. They have roughly the same amount of tritium as we have.

Grozzi told me at Santa Fe he had 4,000 counts per minute per milliliter of tritium - our level - but has not replied to my cable asking him to phone me to see if these results have been confirmed.

Another tritium report comes from Appleby who gave a recent lecture at the Mexican Petroleum Institute in Mexico City. He told me that a worker called Morales had got 10^5 count/min ml there. This would be important but must be confirmed.

After this, my list is more scattered.

Dr. David Schiffrin at the University of Southampton and Dr. R. Armstrong at Newcastle are just beginning. Dr. David Williams at Harwell is not so -ve as he states. He has seen short burst of heat, and a few occasional neutrons and some increase in tritium. He cannot reproduce it - but neither can the rest of us.

I suggest you get in touch with Professor Shengmin Cai, at the Chemistry Department of the University of Peking, Beijing, PRC, who would be a mine of information from the large Chinese groups. I gave you a brief report of the telephone conversation I had with Professor Cai about two weeks ago. Some of the results reported there were positive. Of course, the Revolution may hinder communication.

Only one team claimed that they observed fusion heat, but the excess was not high (I do not know that quantitiy). Professor Cai said it may not be 100% true, because they did not repeat the experiment.

According to the Chinese National Science Research Council, a report signed by several nuclear physists, electrochemists, radio-chemists was sent to NSRC two weeks ago. In the first 20 hours of electrolysis, no neutrons were observed, then at 20 hours, neutron counts start to climb up to 100 times of background. The count was 700$_{\text{(counts)}}$/80 minutes = 8.9 counts/minutes. They charged another Pd of the same size and the same source, they observed the similar phenomena.

DISCUSSION TOPICS, JUNE 22, 1989

I. Pons-Fleischmann effect of excess power

1) Is this effect reproducible? Approximately how many groups working in the field are reporting positive results? How many negative results?

2) How are the calibrations performed and with what reliability?

3) What methods are used to calculate the power (energy) balance?

4) What is the reliability of the positive results? Should one believe results for open cells? Is energy being stored during the charging phase?

5) Are the groups reporting no excess power doing the electrolysis correctly? i.e., Are the size, loading and preparation of the cathodes the same? Are the current density, voltage, electrolyte and induction times the same? What is the reliability of the negative results?

II. Relationship between Pons-Fleischmann effect of excess power and production of particles (n, ^{3}H, ^{3}He, ^{4}He, ^{1}H, gamma rays, x-rays)

1) Which particles, if any, were searched for?

2) If search made, which particles were found and at what intensities?

3) What is background and its reliability for each type of particle?

4) If excess power (heat) is due to fusion, this excess must be associated with an equivalent particle production (even for the very unlikely reactions $d+d \rightarrow {}^4He$ + lattice energy and $p+d$ ^{3}He + lattice energy, the equivalent amount of ^{4}He and ^{3}He must be present!). How close does the heat excess and total particle intensity agree? What are the errors in these quantities? When excess power (heat) has been observed, are there measurements in the same cells showing particles? If so, at what level?

5) If criterion II-4 rules out fusion, what chemical explanations are most likely to account for the P-F effect?

III. Jones effect of neutron (particle) production at very low levels (<0.1 particle sec^{-1})

1) Deuterium source preparation: electrolysis cell (variety of cathodes, electrolytes, charging times, etc.) versus D_2 gas-metal mixtures (at various pressures, temperatures, cycling times, etc.).

2) What type of particle counters were used? How were the counter efficiencies determined?

3) What are the timing characteristics of the counter? Were particle bursts observed? If so, are they spurious or statistically significant?

4) If positive results are obtained, how different are the foreground and background counts?

5) Have energy measurements been made?

6) What is the reliability of the background? How are the background runs mixed with the foreground runs? Has the background been corrected for atmospheric changes, etc.?

7) What is the current status of low-level particle emission? What is the ultimate experimental sensitivity for detection of particles from fusion?

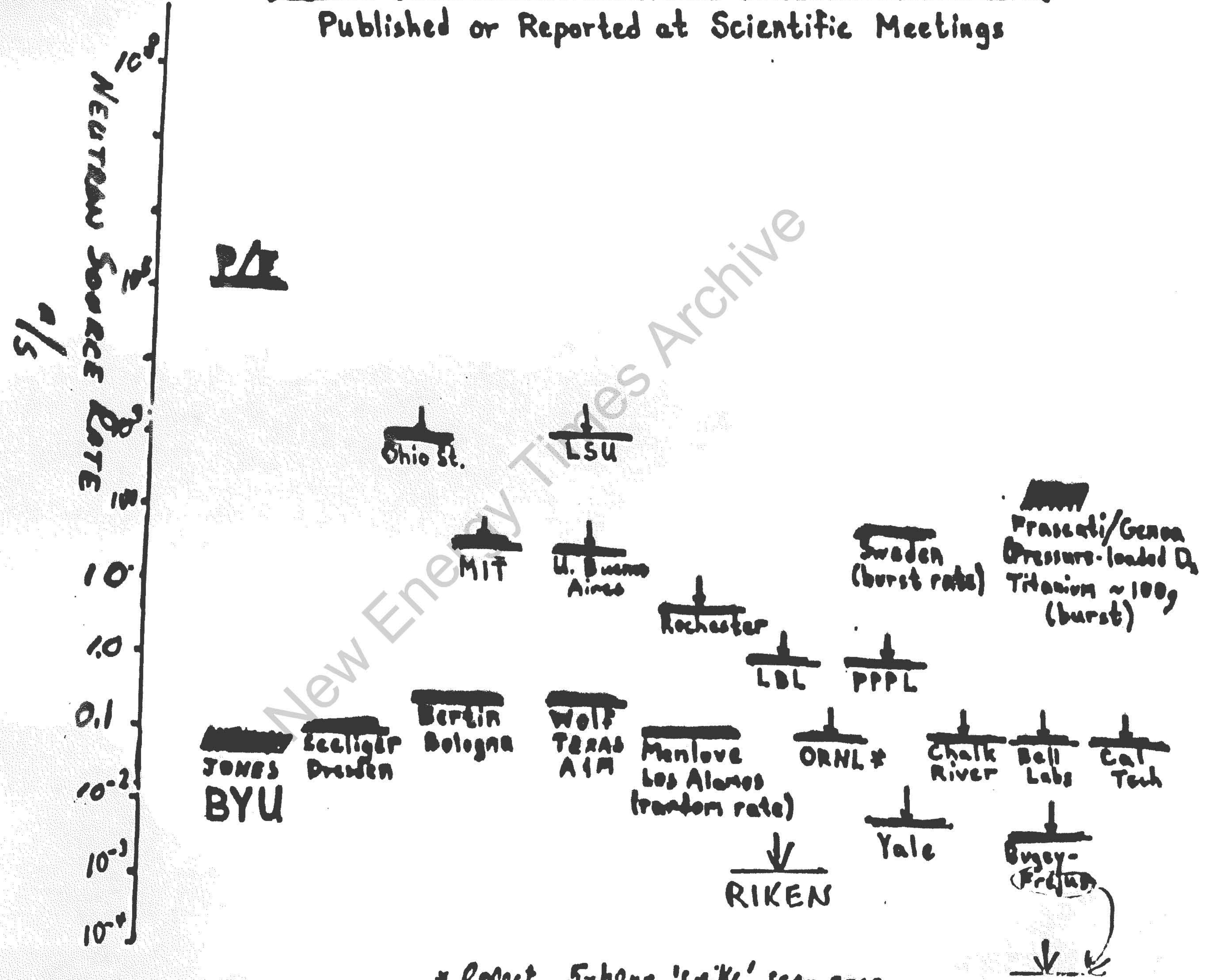
IV. What are the suggested next steps?

1) What new measurements need to be performed? (e.g., all P-F type measurements of power must be simultaneously accompanied by particle measurements; more measurements need to be done with closed electrolytic cells; cathodes producing heat should be examined for particles by independent laboratories).

2) What new collaborative experiments should be encouraged? (e.g.,, in P-F type experiments, personnel, cells, etc. need to be interchanged, in "Jones" type experiments, setups should be moved to laboratories with significantly lower backgrounds).

COLD NUCLEAR FUSION MEASUREMENTS

Published or Reported at Scientific Meetings



* Report 5-hour 'spikes,' seen once

SUMMARY OF COLD FUSION RESEARCH
PERFORMED BY THE
NATIONAL LABORATORIES
FOR THE
JUNE 22, 1989 MEETING
OF THE
ENERGY RESEARCH ADVISORY BOARD
PANEL ON COLD FUSION

"We have carried out detailed neutron detection at extremely low rates interrupted with unexpected spurious, continuous and burst signals in He^3 [illegible] [illegible] [illegible].

Sandia -- "We find multiple detectors provide an excellent way to exclude spurious signals which might otherwise be interpreted as evidence for cold fusion!"

LLNL -- "Many spurious signals appear in one detector and not ~~in the other~~ another and this could be misinterpreted as neutrons."

AMES

1. 1 CELL: 2 RUNS: 2 WEEKS AND 4 WEEKS
   NO 2.223 MeV GAMMAS
   NO 6.257 MeV NEUTRONS
   NO 21 KeV OR 24 KeV X-RAYS
2. D2 GAS: NO NEUTRONS, BUT NOT AS SENSITIVE AS LOS ALAMOS
3. LaHD2: NO 5.493 MeV GAMMAS FROM H-D FUSION

ARGONNE

1. NO NEUTRONS (<1/SEC.):

   3 EXPTS, UP TO 3+ WEEK RUNS

   FALSE POSITIVES; E.G., UP TO 8X BACKGROUND, NOT REPRODUCIBLE

   IMPROVING SENSITIVITY; E.G., TO <20% BACKGROUND

2. NO TRITIUM (<100/SEC.):

   <1/40 UTAH, IF ASSUME RETAINED IN D20

   1 WEEK RUN

3. NO GAMMAS (<50/SEC.): 1/1000 UTAH

4. NO CHARGED H, D, T, He-3, He-4
   (<0.15 P/MIN. >120 KeV):
   2 EXPTS, UP TO 10 DAY RUNS
   FALSE POSITIVE

5. NO "EXCESS" PHOTONS:
   1-25/SEC.--"STANDARD BUT UNEXPECTED"

6. NO HEAT (<0.1 WATT/CC):
   UP TO 10 DAY RUNS, CONTINUING
   UTAH CALCULATIONS CORRECT

BROOKHAVEN

1. WITH YALE:

   (A) UP TO 3 WEEK RUNS

   NO NEUTRONS, NO 5.5 MeV GAMMAS

   (B) UP TO 26 WATTS INPUT

   NO NEUTRONS, NO 23.8 MeV GAMMAS

2. D2 GAS: NO NEUTRONS, NO GAMMAS

3. 4 CELLS:

   SOME NEUTRONS AT FIRST,

   CONTINUING ANALYSIS

4. MUON CATALYSED:
    MIT + BNL AND HARVARD EXPTS.
    RUN ENDED 5/25
    ANALYZING FOR NEUTRONS, GAMMAS AND He

5. TiFeDx UNDER D2 FOR 10 YEARS:
    UNDER ANALYSIS FOR TRITIUM AND He

6. 2 WEEK RUN: NO PROTONS, NO BETAS

7. 4 CELLS: NO HEAT BUT RF

8. SOME THEORY CONTINUING

IDAHO

1. CELLS: NO HEAT, NO NEUTRONS, NO GAMMAS,
   NO TRITIUM

2. GAS:
   - SETTING UP FOR H-D WITH LOS ALAMOS
     BASED ON KOONIN
   - 4000 FEET UNDERGROUND (10-7 COSMICS)
   - POSSIBLY D-T LATER

BERKELEY

1. 2 EXPERIMENTS
   NO NEUTRONS, NO GAMMAS, NO X-RAYS,
   NO CHARGED PARTICLES
   FALSE POSITIVE BURSTS

2. NO CHARGED PARTICLES

3. 5 WEEK RUN
   NO NEUTRONS
   NO GAMMAS (NO 5.5 MeV, NO 23.8 MeV)

LIVERMORE

1. A. 2 CELLS: 156 HOUR RUN

   B. 2 CELLS: 330 HOUR RUN

   NO HEAT, NO NEUTRONS, NO He-3, NO He-4

   C. 1 CELL: 167 HOUR RUN, NO NEUTRONS

2. NO HEAT, NO NEUTRONS, NO He

3. TEXAS A&M: NO He-3, NO He-4
SURFACE: Ca, C, Fe, O, Cl, Li,
Ni, Cu, etc.

4. GAS: "APPEAR TO HAVE DUPLICATED...BURSTS
OF A FEW HUNDRED NEUTRONS"
WILL CONTINUE AND TRY D-T

5. COSMIC MUONS: 10-2 BYU, AS INDICATED BY
EXPT. IN JAPAN

LOS ALAMOS

1. WITH BYU:
   - o SINGLE NEUTRONS AND NEUTRON BURSTS WITH BOTH CELLS AND GAS (<50 MICROSECOND BURSTS)
   - o OBSERVED ION/ELECTRON BURSTS IN GAS
   - o FOR GAS, WILL TRY NEUTRON COINCIDENCES, H2 CONTROL AND D-T (14 MeV NEUTRON RATIO TO 2.5 MeV D-D NEUTRON GIVES REACTION TEMP.)

2. CELLS:
    - SOME CLOSED, NO HEAT, NEUTRONS (ABOVE), MEASURING GAMMAS, X-RAY AND TRITIUM (INCLUDE TEXAS A&M).
    - D/Pd > 1

3. ELECTRON INJECTION: NO HEAT, NO NEUTRONS

4. EXPLOSIVE COMPRESSION: <10 4 NEUTRONS

5. OTHER COLLABORATIONS:

   STANFORD, WASH. STATE AND "THE DOOR REMAINS OPEN TO THE UNIVERSITY UTAH"

OAK RIDGE

1. A. UP TO 3 WEEK RUNS: NO NEUTRONS
   B. 4 CELLS: UP TO 700 HOUR RUNS
   NO NEUTRONS, BUT 1 CELL: "ENERGY
   IMBALANCE OF ~10% FOR SEVERAL HUNDRED
   HOURS...DISAPPEAR... AT 5 DEGREES C
   INSTEAD OF 13 DEGREES C

   CONTINUING

2. 3 CELLS:

- NO GAMMAS, NO TRITIUM
- NEUTRONS: > 3 SIGMA, TWICE, BUT NOT REPRODUCIBLE
- HEAT: 2 CELLS PRODUCED < 20% EXCESS HEAT FOR A FEW HOURS, BUT NOT REPRODUCIBLE

CONTINUING

3. 6 CELLS: UP TO 3 WEEK RUNS

NO NEUTRONS, NO He-4

SETTING UP CALORIMETRY

4. D2-GAS:

- "NO SUSTAINED HEAT" (HEAT BURSTS FROM Pd+D2)
- + 10% NEUTRONS TWICE (LESS SENSITIVE THAN LOS ALAMOS)

CONTINUING

PACIFIC NORTHWEST

1. 13 RUNS: UP TO 20 DAYS
   NO NEUTRONS, NO GAMMAS

2. UNDERWAY: CLOSED SYSTEM, WITH D:Pd >1
   WILL MONITOR HEAT, NEUTRONS,
   GAMMAS, TRITIUM, He-3 AND He-4

3. GAS: 70 HOUR RUN
   NO NEUTRONS

4. TRITIUM ANALYSIS

TEXAS: UP TO 1.96 X 10 6 DPM/ML

UTAH: ONLY 36% INCREASE

5. UTAH: INTERMEDIARY ON ELECTRODE ANALYSIS
OFFERED SURFACE, MICROSTRUCTURAL
AND CHEMICAL ANALYSIS

6. AT PRESENT: 2 MANYEAR/YEAR

PRINCETON

- CELLS, GAS (INCLUDING Nb, ALUMINA, QUARTZ AND FELDSPAR) AND FRACTURING (e.g. ZR/A1/V PELLETS
- NO NEUTRONS (< 1/sec.)
- NO 5.4 MeV GAMMAS (<3/sec.)
- CONTINUING FRACTURING NON-CONDUCTORS AND METALS WITH INCOMING GRADUATE STUDENT

SANDIA

1. UTAH TYPE CELLS: UP TO 45 DAY RUNS

   NO HEAT, NO TRITIUM, NO NEUTRONS

   CONTINING WITH CLOSED SYSTEM

2. BYU TYPE CELLS:

   NO NEUTRONS

   INCL. UNDERGROUND: 100/HR OR BURSTS OF 50

   FALSE POSITIVES

3. THIN-WALL CELL: 1/10 BYU

4. GAS: NO NEUTRONS (UNDERGROUND SYSTEM)
5. PLASMA LOADING: 0.9 D/Pd, NO NEUTRONS, NO CHARGED PARTICLES
6. ION IMPLANTATION: 1.6 D/Pd, NO CHARGED PARTICLES
7. COLLABORATED WITH ROCKWELL ON He ANALYSIS, INCL. TEXAS A&M: NO He-3, NO He-4
8. STUDIED LOADING KINETICS, D-D SPACING AND POWER BALANCE CALCULATIONS

9. SUMMARY: KINETICS SPINOFF, AND "UNEXPECTED" FALSE POSITIVE SINGLE NEUTRONS AND NEUTRON BURSTS

Report to Energy Research Advisory Board on Cold Fusion Research at the Ames Laboratory

The Ames Laboratory group has carried out a number of experiments to search for cold fusion both on Pd-D_2O cells and Ti-D_2 gas systems. Also, the compound $LaHD_2$ was examined.

In the Pd-D_2O cell experiments, the electrolyte was 0.1 molar LiOD in 99.8% D_2O. A constant current source supplied a current of 1 A and the electrolyte temperature was monitored by a thermocouple. The anode was Pt wire and in the first experiment the cathode was a rod of cast Pd 2 mm in diameter. The run lasted for ~ 2 weeks. In the second run lasting for ~ 4 weeks, the cell was kept under dry N_2 and the D_2O was replenished by a "chicken feeder." A cathode of single crystal Pd 4 mm in diameter was used. Neutrons were monitored by a BF_3 counter wrapped in Cd foil to reduce background and surrounded with paraffin. x and γ radiation was monitored by a Ge detector with a thin Be window. The range of measurements for the Ge detector was 10 keV to 7 MeV.

The results from the Pd-D_2O cell experiments were all negative. Although no calorimetry was carried out, no unusual temperature excursions were observed. A search was made for neutrons and γ-rays at 2.223 and 6.257 MeV from neutron capture in H and D, respectively. Pd x-rays at 21 and 24 keV were monitored as a signature for charged particle production. No neutron, x, or γ radiation above background levels was observed. Thus, we obtained null results for Pd-D_2O cell fusion at the level claimed by Fleischmann and Pons. The experiments, however, were not sensitive enough to test for fusion at the level claimed by Jones. By postmortem analysis of the samples, it was found that the concentration of D in the Pd electrodes maximized in about 4 hours at the level of 0.7 to 0.8 deuterons per Pd atom.

We searched for neutrons emitted from a Ti-D_2 gas system. In the experiments, 20-30 g of Ti sheet metal, in the form of strips, chips, shavings, and powder, were subjected to a series of heating and cooling cycles in which D_2 gas at pressures up to 50 atm was added to Ti at temperatures up to 1020K. TiD_x was produced with x as high as 1.9. The TiD_x was subjected to a number of cycles in which it was cooled to 77K and allowed to warm to room temperature. No neutron counts above background were observed during the temperature cycling, deuteration, or dedeuteration of the Ti sample. We did not observe neutrons at the level claimed by Scaramuzzi and coworkers, whose procedure we closely emulated. Our experiments were not sensitive enough to test the results of the Los Alamos Group presented at the Santa Fe Conference.

It has been suggested that the fusion rate for the H-D molecule might be greater than for the D_2 molecule. Therefore, we monitored a sample of $LaHD_2$ using a Ge detector to search for the 5.493 MeV γ ray emitted in the $p+d \rightarrow {}^3He + \gamma$ reaction. In a two-week run no evidence was found for emission of the above γ ray.

Our searches for cold fusion have concentrated on observations of neutron and electromagnetic radiation from Pd-D_2O cells, TiD_x, and $LaHD_2$ systems. No radiation of any kind above background was observed. These results were presented in a poster at the Santa Fe Workshop and a detailed paper is being prepared for the *Journal of Fusion Energy*.

ARGONNE NATIONAL LABORATORY
9700 South Cass Avenue, Argonne, Illinois 60439

312-972-3504

June 8, 1989

Dr. David Goodwin, Technical Advisor
ERAB Cold Fusion Panel
ER-20.1, GTN
U. S. Department of Energy
1000 Independence Avenue, SW
Washington, DC 20545

Dear Dr. Goodwin:

I am enclosing a copy of the Interim Report of Cold Fusion Experiments at Argonne National Laboratory dated May 12, 1989. The two page summary at the beginning of the report should serve the Panel's needs. At this point in time a much reduced effort is continuing at ANL, principally to follow up on some calorimetry experiments and to finish up some increased sensitivity neutron detection measurements on electrolytic cells.

If I can be of further assistance, please contact me.

Sincerely,

Frank Y. Fradin
Associate Laboratory Director
for Physical Research

FYF:mao
encl.

xc: A. Schriesheim

Summary of Cold Nuclear Fusion Experiments at ANL

May 9, 1989

Experiments and calculations at Argonne have tested most of the aspects of the electrochemically induced fusion experiments of Fleischmann and Pons[1] and of Jones et al.[2] An experiment has also begun to test the fusion claims from high pressure absorption of deuterium gas in titanium, claimed by Scaramuzzi et al (Frascati, Italy).[3]

No observations at Argonne confirm the claims of cold nuclear fusion.

The work is summarized in 6 categories: measurements of neutrons, protons, tritium, gamma rays, light and heat.

1. Neutron observations

Three ANL experiments (#'s 3,4,5 in the table below) clearly show less neutron production than the rates of reference 1, but their limits of observation are higher than the rates of reference 2. Carpenter et al observe lower rates. However, they have a small electrolytic cell, and after scaling in size, their rate limit is double that of Jones et al.

Expt #	1 ref.2	2 ref.1	3 Freedman et al --> ANL	4 Carpenter et al	5 Melendres & Greenwood	units
Material	Pd/Ti	Pd	Pd	Ti	Pd	
Volume	2.4	1.2	0.3	0.2	0.8	cm^3
Surface area	?	12	6	2	3	cm^2
N(obs)	.0041	.1		<.015	<.1	sec^{-1}
Efficiency	.01	$2.4.10^{-6}$		.2	.15	
N produced	.41	4.10^4		<.075	<.7	sec^{-1}
N prod/V	.17	$3.3.10^3$		<.375	<.88	$s^{-1}.cm^{-3}$

2. Proton and charged particle observations

Rehm et al use a very small Pd cathode (area 0.5 cm^2) but observe

---

[1] S. Fleischmann and M. Pons, Electrochemically Induced Nuclear Fusion of Deuterium, J. Electroanal. Chem. 261, 301 (1989).

[2] S.E. Jones et al, Observation of cold nuclear fusion in condensed matter, Nature, 338, 737 (1989).

[3] Scaramuzzi et al, "Evidence of Emission of Neutrons from a Titanium-Deuterium System," submitted to Europhysics Lett.

0.15 protons/minute, for events with energies greater than 120 keV, with and without cell current. This corresponds to a rate of 5.10^{-3} s^{-1} at the source, a rate of 2.10^{4} less than the rate needed for the heat production in ref.1.

Zaromb et al have found no charged particles (e.g. H^{+}, D^{+}, T^{+}, $^{3}He^{++}$ or $^{4}He^{++}$) of energies large enough to pass through 0.002 cm of Pd. Their lower rate limit is uncertain.

3. Tritium production

Melendres, Greenwood and Bowers measured the tritium yield as less than 100 atoms/second. Assuming that 90% of the tritium remains in the palladium, this corresponds to 1/40th of the rate compared to reference 1.

4. Gamma ray production

Melendres and Greenwood obtain an upper limit of 50 gammas/second from their cell. This is a factor of 10^{-3} of that claimed from reference 1.

5. Light production

Berry et al have observed low photon yields (typically 1-2 per second observed) in Pd cells with both D_2O and H_2O in HNO_3 with and without LiOH. The yields depend on the PH value of the electrolyte, becoming close to zero for basic solutions - this reduction in yield mimics the loss of signal seen in reference 2 for the neutron yields. Except for one experiment in D_2O and HNO_3 alone, no excess light yield above 1 photon/sec is observed.

6. Heat production

Redey et al have compared the heat production in two identical Pd/Pt cells, one containing LiOH and H_2O, the other LiOD and D_2O. After adjusting for the electrochemical potential differences, no significant excess heat production was observed over a time period of 10 days running.

A further measurement with two different Pd/D cells is now underway, and shows no excess heat production.

Nagy has checked the excess heat production calculations of Fleischmann and Pons (reference 1). Using reasonable assumptions about the electrolysis, he finds all but 2 of the excess enthalpy results correct. However, he claims that this excess heat could be produced by an (unknown) chemical reaction.

Summary of BNL Cold Fusion Research

In summary, we find no evidence in any experiment of a nuclear fusion process. In a couple of experiments there is evidence of rf emission from samples, which could mimic true counts in certain situations.

The Yale-BNL Experiment

Six NE213 neutron detectors were set up surrounding electrolytic cells with various types of electrodes and electrolytes and run for periods of up to 3 weeks. Cosmic-ray veto counters were used to reduce background induced events. The level of neutrons detected is roughly a factor of 100 below that of Jones et al. and roughly a factor of 10^6 below the original claim of Pons and Fleischmann. In addition a search for the 5.5 MeV gamma ray from the p + d reaction was made with a negative result. A paper has been accepted by Nature.

Searches With Large NaI Detectors

Electrochemical cells with Pd and Ti electrodes have been placed in 25 cm x 30 cm long NaI(Tl) annular detector which butts up against a second large 25 cm x 36 cm NaI(Tl) crystal with very high energy resolution and efficiency for up to 100 MeV gamma rays. (The particular interest was the possible existence of the 23.8 MeV gamma ray from d-d capture to He^4 plus gamma). The whole assembly is surrounded by a plastic anticoincidence shield to veto on cosmic rays. Neutrons are detected by moderating them before observing capture gamma rays on either p or I. No evidence of gamma rays or neutrons above background has been observed with up to 26 watts of input power.

In addition, many attempts with the same setup have been made to try to reproduce the Frascati measurements. Vanadium + Deuterium, Titanium + Deuterium, and FeTi + Deuterium combinations have been tried -- cycling the temperature from -200°C to +100°C and pressure of the gas from 20 psi to 250 psi. Contact with Professor Scaramuzzi of Frascati was made, who guided researchers through his process step by step. No signals above background have been seen for either gammas or neutrons.

A New Neutron Experiment

Twenty-four BF3 counters with a cosmic ray veto surround 4 LiOD electrolytic cells with Pd rods and foils. Cosmic ray veto counters are used. The setup has been run with some as yet unexplained effects. In particular, when the electrodes are first cleaned and put in the cell counts appear (believed to be rf emission) and then disappear in steady-state running of the cell. The counters have also been shown to give counts with increased humidity. Work is continuing.

Muon Catalyzed Fusion

Two experiments (MIT + BNL, Harvard) investigating muon catalyzed fusion in Pd and Ti electrodes in electrolytic cells were carried out at the stopped muon beam line at the AGS. Measurements were made of neutrons, gammas and He. The run ended May 25. Analysis is continuing.

Analysis of an Old Deuterided Sample of $TiFeD_x$

Samples of $TiFeD_x$, which have been under deuterium gas pressure for 10 years, are under analysis for both tritium and He content.

Proton Emission from Thin Foils

A 1 mm Pd foil in a D_2O solution has been studied for emission of betas and protons with a Si detector (which has a Be window) over a 2 week period. So far no unexplainable counts.

Calorimetry

Four "Pons and Fleischmann" cells have been running looking for excess heat. To date none has been observed.

In addition, a repeatable sequence involving the warming of preloaded (with either H or D) wire and sheet Pd electrodes in a constant voltage U-tube reveals detectable bursts of rf accompanying the rapid release of the adsorbed species (H or D). For equivalent electrical conditions the response of the deuterium loaded electrode occurs at a significantly lower temperature.

Theory

A number of theorists have been looking at how hydrogen is stored in various compounds. The conclusion in both theory and some experiments is that the separation distance of the hydrogen (deuterium) atoms in a metal or compound is always GREATER than the free molecule. Thus it is not clear why one would induce fusion by putting deuterium in Ti or Pd. Specific calculations are being performed on the cohesive energies of Pd and PdLi with and without deuterium. The results will be used to estimate the energy difference between the "short bond" deuterium (analogous to D_2, bond length 0.7Å) and the "long bond" deuterium (like that in Pd hydride 2.0Å).

United States Government

memorandum

Department of Energy
Idaho Operations Office

DATE: June 16, 1989

SUBJECT: Energy Research Advisory Board Update - Cold Fusion at Idaho National Engineering Laboratory

TO: Dr. David Goodwin, Special Assistant
to the Associate Director
Office of High Energy and Nuclear Physics
DOE-HQ, ER-20.1

Idaho National Engineering Laboratory (INEL) is conducting several cold fusion experiments, as described below. Our major effort has been to attempt to duplicate the University of Utah observations. We are also studying the low rate fusion effects reported by researchers at Brigham Young University and elsewhere.

Using a calorimeter, which is approximately a factor of ten more sensitive than the University of Utah's instrument, we have conducted measurements using light water, heavy water, and light/heavy water mixtures. Within the range of experimental parameters employed to date, no excess heat, excess tritium, or neutron/gamma radiation above background have been measured at our laboratory. A paper describing the INEL calorimetric experiment was presented at the Workshop on Cold Fusion Phenomena, at Sante Fe, 23-25 May 1989.

INEL, in collaboration with M. Paciotti of Los Alamos, is planning to conduct experiments attempting to duplicate the "Frascati effect," that is, the apparent generation of fusion neutrons in bursts. We plan to use protium-deuterium mixtures, since the calculations of J. Cohen at Los Alamos and S. Koonin of Caltech suggest this may enhance the rate of cold fusion. We may also try a deuterium-tritium mixture in the later phase of the experiment. The critical portion of our measurements will be conducted 4000 feet underground in an Idaho silver mine. At this level, the cosmic-ray flux is reduced by a factor of ten million. By comparison of experiments running at the surface and underground, we can measure, and subtract, the cosmic-ray background in these experiments.

For additional information please contact Dr. Stephen Lien (FTS 583-1231) or Dr. Gus Caffrey (FTS 583-4024).

Dr. Stephen C.T. Lien, Chief
Advanced Technologies Branch

6/15/89

SUMMARY OF STUDIES ON "COLD FUSION" AT LBL

1.) Detection of Radiation During the Electrolysis of Pd Cathodes in Heavy Water

John Porter, Materials and Chemical Sciences Division
John Rasmussen, Nuclear Sciences Division

Radiation detection experiments were conducted using a "double blind" configuration. Nominally identical, cast palladium samples were placed in identical cells labelled A and B, and the experimenters did not know which cell contained the heavy water. The electrolyte was 1M LiOD in D_2O (or LiOH in H_2O). Counting was done with two sets of detectors. Counting setup #1 was well shielded and the enclosure filled with water and paraffin to thermalize neutrons efficiently. Two intrinsic Ge detectors and one liquid scintillator neutron counter were positioned inside for x-ray, gamma, and neutron counting. Setup #2 had a ^3He neutron spectrometer and an intrinsic Ge detector for energy analysis of neutrons, gammas and x-rays. Setup #2 also had a plastic charged particle scintillator placed atop the ^3He detector to monitor the cosmic ray incidence. The twin cells A&B were exchanged every 24 hours between the two counting setups. After counting for six full days with current in both cells maintained at 100 mA (area ca. 5 cm^2), the current was raised to 250 mA for two days of counting (one day for each cell in both counting setups) and finally raised to 400 mA with the addition of sodium sulfide to poison D-D recombination on the surface. The D/Pd ratio at the end of the experiments was determined (by weighing) to be approximately 0.7. Integrated over the entire counting period, the difference in radiation emission between cells A & B (i.e., the light water cell and the heavy water cell) was within 1σ of zero. The presence of several "bursts" of apparent signal in the detectors was noted during these experiments. The use of simultaneous pulse height/shape analysis and multichannel scaling and the use of a second detector allowed the origin of the bursts to be determined as mechanical and/or electrical interference, i.e., the bursts were artifacts. These experiments established an upper limit of 1.2×10^{-23} neutrons per D-D per second. Comparable upper limits (i.e., 10^{-23}) were established for other forms of Pd as well, in particular, cold-drawn wire, electrodeposited Pd, Pd black, and e-beam evaporated Pd.

In another set of experiments, the emission of charged particles was detected using a Si surface barrier detector placed directly behind a Pd foil cathode in a cell with a "chimney" configuration. The Pd foil was 76 um with a 100 nm gold layer evaporated on the gas (detector) side as a diffusion barrier. The experimental protocol was to take the foreground counts with the foil acting as a cathode, and the background counts with the foil acting as an anode. The electrolyte was 1M LiOD in D_2O. Electrolysis was conducted at a constant current density of ca. 30 mA/cm^2. After two weeks of electrolysis, no foreground signal was detected over the background, which placed an upper bound of 7×10^{-25} protons per D-D per second. The D/Pd ratio was determined by chronocoulometry to be 0.82.

2.) Detection of Energetic Charged Particles Emitted from Pd Cathodes During Electrolysis of Heavy Water

John Porter, Materials and Chemical Sciences Division
Buford Price, Physics Department, University of California

In this experiment, CR39 plastic sheets were patterned with 100nm gold then 1um Pd using an electron beam evaporation system. Two identical electrochemical cells were formed, connected electrically in series. One cell contained 1.0M LiOH, the other 1.0M LiOD. Both electrodes in each cell were the gold-backed palladium. A constant current of 7.96 mA/cm^2 was passed through both cells; one electrode acted as the cathode and the other as the anode in each cell. After electrolysis, the electrodes were peeled away, the plastic washed with concentrated HCl and light water, dried under nitrogen, then etched and tracks identified and counted. Again, a single-blind protocol was adopted, whereby the person counting tracks was unaware of the identity of the electrode which had been in contact with the plastic. No significant differences in track density were found between the four "active" regions of the plastic or the "inactive" regions of the plastic outside the electrochemical cells placing a limit on the rate of fusion on the order of 4×10^{-24} fusions per D-D per second.

3.) Detection of Radiation from Pd Cathodes During the Electrolysis of Heavy Water

Eric Norman, Nuclear Sciences Division
Darleane Hoffman, Nuclear Sciences Division

Two types of D_2O cells containing electrodes and electrolytes similar to those described in Refs. 1 and 2 were operated over a period of five weeks. Fast neutrons were searched for using liquid scintillators and dosimetry film. Prompt gamma rays were searched for using NaI detectors; induced radioactivity in the electrodes was searched for using Ge detectors. Background measurements were conducted with the D_2O cells turned off and with an operating H_2O cell. Measurements of the masses of palladium electrodes before and after electrolysis showed that the number of deuterium atoms loaded was greater than 0.5 per Pd atom. No excess of neutrons or gamma rays above background was observed in any of the experiments. From the neutron measurements we have established an upper limit of 2.1×10^{-24} [$d+d \rightarrow {}^3He + n$] reactions per second per deuteron occurring in our Pd electrode. Similarly, the lack of 23.8-MeV gamma rays established an upper limit of 2.7×10^{-24} [$d+d \rightarrow {}^4He + \gamma$] reactions per second per deuteron in the same electrode. In some runs, a small (15%) amount of H_2O was added to the D_2O to search for the $d + p \rightarrow {}^3He + \gamma$ reaction. No excess of 5.5-MeV gamma rays above background was observed and an upper limit of 1.8×10^{-23} such reactions per proton per second in our Pd electrode was established.

1. M. Fleischmann and S. Pons, preprint

2. S.E. Jones et. al., preprint

Lawrence Livermore National Laboratory

June 16, 1989

Dr. William Woodard
Energy Research Advisory Board
U.S. Department of Energy
Washington D.C.

Dear Dr. Woodard,

Please find, as you requested, a short summary of the experimental and theoretical program at the Lawrence Livermore National Laboratory on the subject of cold fusion. Our first reactions to the initial reports of Pons and Fleischmann were those of surprise because they were inconsistent with our present understanding. However the importance of such a new approach to fusion was so great that a very large number of our scientists began in earnest to examine the reported experiments. It rapidly became clear that there were two classes of experiments.

(1) Those that measured excess heat from D_2 loaded Pd electrodes in an electro chemical cell. (Pons and Fleischmann, Srinivasan, Huggins,....)

(2) Those that measured a very small number of excess neutrons from D_2 loaded Pd electrodes in electrochemical cells, however these cells produced no excess heat. (Jones et al, Frascatti laboratory results)

Our calculations and theoretical research have shown that there is no reason to believe that D_2 in a palladium matrix should fuse and cause the observed heat or the observed neutrons. Furthermore we have been unable to measure enhanced heat production in D_2 loaded palladium-electrode electrochemical cells. In one case (Srinivasan at Texas A&M) we have examined palladium from cells that appeared to have generated excess heat but we see no evidence of fusion -- no He^3 or He^4, tritium, or neutrons.

In our experiments that fall in class (2) above, which include the initial experiments of Jones et al, we have measured no neutrons. In experiments with D_2 pressured titanium metal, we, LANL, Frascatti and others may have seen bursts of a few neutrons, but we are not yet convinced of the accuracy of these measurements. While we are convinced that this class of experiments has produced no useful fusion or accompanying heat, there are some curious observations that should be explained, but at a low funding level.

In summary we believe that at the National Laboratory level there is little additional work to do in the area of cold fusion. Please see the attached sheet for a more detailed explanation of our results. Thank you for this opportunity to describe our results.

Sincerely,

John H. Nuckolls
Director

June 16, 1989

LLNL REPORT ON COLD FUSION

With the appearance of reports on "Cold Fusion", scientists at the Lawrence Livermore National Laboratory began an increasingly sophisticated series of experiments and calculations to explain these phenomena. These experiments can be categorized as follows: (a) simple experiments to replicate the Utah results, (b) more sophisticated experiments to place lower bounds on the generation of heat, and production of nuclear products, (c) a collaboration with Texas A&M to analyze electrodes and electrolytes for fusion by-products in a cell producing 10% excess heat (we found no by-products), and (d) attempts to replicate the Frascati experiment that first found neutron bursts when high pressure deuterium gas in a cylinder with Ti chips is temperature cycled.

We failed in items (a) and (b) to replicate either the Pons/Fleischmann or Jones phenomena, and appear to have duplicated the Frascati results, (d). Summaries of (b) through (d) are described below, as is a theory effort based on cosmic ray muons.

Electrolytic Cells

A typical experiment involved comparisons of electrolytic cells using D_2O and 0.1 M LiOD with cells using H_2O and 0.1 M LiOH. Palladium wires 1 mm in diameter were used in the two runs described below, the first were simply swaged and drawn, but since there were reports that remelting was necessary we annealed the wire for the second run for 3 hours at 600°C. The first pair of cells ran for 156 hours in a common bath, each with a 35 cm long swaged wire, with current densities starting at 90 mA/cm^2, increasing to 270 mA/cm^2, and then to 450 mA/cm^2. The slight temperature difference between the two cells remained essentially constant throughout the run, that is there was no excess heat difference between them. Using relatively low efficiency neutron detectors, no neutrons above background were observed. An analysis of the Pd for ^{3}He and ^{4}He was negative, setting limits of a few times 10^{10} atoms per gm. After cutting a length of this wire from the above D_2O cell it was run in another thin-walled cell for 4 more days with a Geiger counter near it. No counts above background were observed. A second experiment used a pair of cells with annealed Pd, and it ran for 330 hours at a current density of 230 mA/cm^2 with similar null results. Analysis of that wire showed no helium buildup either. In both cases the thermometry might have missed seeing excess heat at the 10% level.

One cell similarly prepared to the one described above was setup for sensitive neutron counting. The cell ran for 167 hours and featured a proton recoil telescope detector that eliminated all background counts, and it used a sensitive liquid scintillator (7% efficiency, absolutely calibrated, with neutron/gamma pulse shape discrimination). The latter set a limit of 0.2 neutrons/sec from the 27 g Pd wire, half the level reported by Jones at BYU with a 5 g sample.

Several other experiments with electrolytic cells were run in a second independent group. Their experiment was designed to test for helium buildup in Pd, for neutrons, and for excess heat. Calorimetry with a minimum thermal detectivity of about 2% of the input electrical power was used. Similar (null) results were found by this group. If the excess heat is a 10% effect, as observed at Texas A&M, then this calorimeter has sufficient sensitivity and no effect was observed.

Collaboration with Texas A&M

We analyzed samples of Pd from a cell run at Texas A&M by Srinivasan, who reported 340 mW heat flow into their sensitive microcalorimeter with 300 mW heat input, indicating an excess heat generation of 40 mW. However, it should be remembered that an additional power input of 150 mW was needed to separate the D_2O molecules. To the level of 3×10^5 ^3He atoms and 5×10^8 ^4He atoms in the sample (about 20 mg) there was no helium generation in the wire. This is many orders of magnitude below the level associated with 40 mW of fusion power for one hundred hours. Surface analysis with Auger and SIMS techniques revealed a substantial layer of material (Ca, C, Fe, O, Cl, Li, N, Cu and traces of other elements) plated out on the surface. These gave no clue as to possible excess heat generating mechanisms however they indicate suspicious additional electrochemical mechanisms. An analysis of the electrolyte before and after the run showed no change in the tritium level in the original electrolyte.

Neutron Burst Experiments

Experiments using pressurized deuterium cylinders loaded with Ti in various forms, similar to the Frascati experiments, were carried out by several groups at Livermore. In a large number of runs, cycling the temperature from ℓN to room temperature, the results were null. Very recently, with detector efficiency improved to 15%, with higher pressure operation to 60 Atm, and with a pair of coincidence detectors incorporating burst mode triggering in the detection circuits, one group observed what appear to be bursts of a few hundred neutrons. These do not correlate with the temperature of the cylinder at the time of the bursts, which is contrary to data from LANL. Consistent with Sandia, it requires multiple detectors and the observation of coincident signals to place some confidence in the results. Many spurious signals appear on one detector but not another, and this could be missinterpreted as neutrons. At present, the temporal signals are being studied to assure ourselves that the signals are indeed neutrons. Plans to repeat this in DT gas have been made.

Muon Theory

A theory to explain that the fusion neutrons observed by Jones etc. were generated from cosmic muons was developed here. The theory falls short by about two orders of magnitude to explain the level of neutrons seen by Jones. It was found that charge exchange with deeply trapped electrons around the Pd (or Ti) limits the muon to catalyzing at most a dozen events. In 13% of the muon catalyzed D-D reactions the muon sticks to the resulting He atom, and must subsequently be reionized by deeply trapped (a few kV) electrons. Instead, however, the muon charge exchanges. Further, experiments in Japan with accelerator generated muons, reported recently in Santa Fe, definitively set an even lower limit to muon catalyzed reactions then the above theoretical explanation.

COLD FUSION RESEARCH AT LOS ALAMOS NATIONAL LABORATORY

A broad spectrum of cold-fusion investigations is in progress at Los Alamos. Research activities include:

1. Careful low-level neutron measurements on electrochemical cells and on pressurized D_2 cylinders.
2. Systematic studies of electrochemical cells under various parameters.
3. Electron injection solid state D-D fusion in Pd-Si cells.
4. Explosive compression of D-loaded Pd.
5. Theoretical support and modeling.

NEUTRON MEASUREMENTS

Low-level neutron producing experiments have been successfully performed at Los Alamos with participation by Brigham Young University staff. Experiments have consisted of random and time correlated neutron measurements on electrolysis cells and on pressurized D_2 gas cylinders containing Ti, Pd, or V metal. Four high-efficiency neutron coincidence counting systems are located in a low background environment. The counters provide information on total and time correlated neutron production. Two of these systems have an inner and outer circle of helium-3 tubes that provide information on the average energy of the source neutrons. A neutron counter recently constructed contains three rings of helium-3 filled tubes and an overall efficiency of about 35% for ^{252}Cf spontaneous fission neutrons.

Measurements on D_2 gas cylinders containing Ti and on electrolysis cells with Pd and Ti cathodes resulted in the discovery that neutron emission does occur, but in low yield, short-lived bursts (<50 μs). The sporadic bursts occasionally come from the pressurized D_2 cylinders with Ti, V, or Pd metal during warm-up cycles from liquid nitrogen to room temperature. It is proposed that the neutrons are resulting from local "hot fusion" associated with accelerating electrical potentials produced by microscopic fracturing and cracking in the D_2 gas-metal interactions.

Early results were reported at the Santa Fe Conference, and a manuscript describing results up to a couple of weeks ago has been submitted to Nature.

If microscopic cracking is the source of the neutrons, large numbers of accelerated electrons and ions should occur. Recently, a pressurized D_2 cylinder was modified into an ionization counter, and several bursts of ion/electron emission were observed. The next step will be to place the ion counter in a neutron counter and look for ionization-neutron coincidences.

As soon as neutrons can be produced in a reproducible manner, control experiments with H_2 gas and planned experiments with DT gas will be performed. If fusion is resulting from the electrical potential developed across microcracks, the DT reaction (14-MeV neutrons) rate should be considerably larger than the DD reaction (2.5-MeV neutrons) rate.

ELECTROCHEMICAL CELLS

Several teams are conducting experiments with electrochemical cells. This work was evolved from early attempts to duplicate the Fleischmann-Pons experiment to developing techniques to increase the D/Pd ratio in the cathode. Although several closed-system calorimeters with hydrogen-oxygen recombination are now almost ready to use, the main effort has been to develop cells that produce fusion signatures (neutrons, gamma rays and/or Pd x-rays) and obvious excess heat; the latter has not been observed. As discussed above, low-level neutron emission from Jones type cells with Ti cathodes has been observed at Los Alamos, perhaps associated with cracking in the deuterated Ti.

Substantial progress has been made in increasing the D/Pd ratio in cathodes of electrochemical cells. Both by alloying with Li or Rh, or by surface poisoning with chemical additives to the LiOD electrolyte, D/Pd ratios greater than 1 have recently been achieved.

Careful assay of the input D_2O composition, tritium buildup in the cell, and precautions to ensure that normal water vapor does not enter and dilute the cell are important aspects of these measurements. Control cells with normal water are operated in parallel. Several tritium counters are available at Los Alamos, and ^3T assay support has been provided to Texas A&M.

SOLID STATE FUSION EXPERIMENTS

The intent of this work is to take advantage of the fact that small increases in the mass of the electron can produce large increases in the D-D fusion rate.

Solid-state cells were made that allow the injection of electrons into Pd from Si. The injected electrons, under certain momentum conditions, can behave as if they had an increased mass. If the Pd is also loaded with D, the combination might enhance the conditions for fusion. The cell is constructed of alternating layers of Pd and Si powders and is pressurized with D_2. Electron injection is effected by electrical pulses and one looks for thermal effects and time-correlated neutron emission coincident with the electrical pulses. Thus far, these signatures have not been observed.

EXPLOSIVE COMPRESSION

An experiment was performed in which deuterated Pd foil was explosively compressed. Both on-line neutron counters and later counting of activation foils indicated the neutron flux was below the limits of detection ($< 10^4$ total neutrons from the device).

THEORY AND THEORETICAL SUPPORT

Considerable theoretical work has gone into the proposed fracturing process that could generate neutrons. If suitable conditions can be found that give reproducible neutron generation, the use of DT gas will help to provide an estimate of the reaction temperature at the location of neutron production. The ratio of 14 MeV neutrons from the DT reaction to 2.5 MeV neutrons from the DD reaction contains the temperature information.

OUTSIDE COLLABORATIONS

Los Alamos is currently collaborating with researchers from Stanford, Brigham Young, Texas A&M, and Washington State Universities. The door remains open to the University of Utah collaboration.

OAK RIDGE NATIONAL LABORATORY

COLD FUSION STATUS

Summary

Four groups at the Oak Ridge National Laboratory (ORNL) are currently working on "cold fusion" experiments. Three are using electrochemical cells to investigate the Fleischmann/Pons effect and one is using pressurized D_2 plus Ti or Pd to investigate the effects first reported by the Frascati group.

None of the groups has confirmed the production of excess heat or of fusion by-products (neutrons, gammas, tritium, ^{4}He). Experimental sensitivities would have clearly shown effects at the levels reported by the Utah or Frascati groups. Two of the groups would have been able to detect neutrons at the levels claimed by Jones at BYU. All of the groups have, however, observed anomalies at one time or another, some of which have not yet been satisfactorily explained, none of which constitute confirmation of "cold fusion." Details are given below under the name of each principal investigator.

1. D. P. Hutchinson et al.

Attempts to duplicate the results reported by the University of Utah began at the end of March. The first cells had Pd foil cathodes and were diagnosed for neutrons by a pair of NE-213 scintillator detectors, using n-γ discrimination, with an overall efficiency of 13% for neutron detection. No significant counts were observed corresponding to an upper limit of 10^{-23} to 10^{-24} events/sec/deuterium pair for a one-hour run. On April 11 two cells containing 3-mm o.d. cast Pd rod cathodes were started and operated for over three weeks with the same result.

A parallel calorimetry effort was begun to investigate the "excess heat" reported by the Utah group. The first two experiments utilized 6.35-mm o.d. x 100-mm extruded Pd rods obtained from Johnson-Matthey. Both rods were annealed at 900° C for four hours, and one was pre-charged with D_2 to a concentration of 60%. The current density was 250 mA/cm^2, with an electrolyte of 0.2 M ^{6}LiOD. A third cell, using an annealed 6.35-mm o.d. x 100-mm pre-charged Pd rod and 0.1M electrolyte, and a fourth cell, using a 13-mm o.d. x 100-mm cast rod in a 0.2 M electrolyte, were added later. The first two cells have been in operation for over 700 hours to date. One has indicated an apparent energy imbalance of ~10% for several hundred hours, and this apparent imbalance has been shown to disappear if the experiment is run at 5° C instead of 13° C. This effect is not understood. The calibration system is being redesigned to check for systematic errors. Approximately two weeks will be required to implement these changes. No neutrons have been observed during this period of power imbalance (upper limit 10^{-24} events/sec/deuterium pair). The remaining cells indicate power balance within ~1%.

2. C. D. Scott et al.

Three different electrochemical cells have been run using D_2O with a LiOD electrolyte and a Pd cathode. Insulated glass electrolysis cells approximately 4-cm-diam x 10 cm were used with Pd cathode rods of 0.28- to 0.55-cm-diam x 8- to 9-cm operating at 100-400 mA/cm^2. Heat removal was determined by the temperature increase of the forced flow of cooling water. Neutron flux was measured by a NE-213 scintillator with n-γ discrimination . Typical sensitivity was $\approx 3 \times 10^{-24}$ fusions/deuterium-pair/sec for a four-hour run. A NaI gamma-ray spectrometer was also used for detection of neutrons via a polyethylene converter, but it had somewhat less sensitivity. The tritium concentration was measured periodically in the electrolyte.

There have been no sustained positive results. There have been two separate occasions with two different Pd electrodes when the neutron flux exceeded three standard deviations above the background previously measured, although no simultaneous background measurements were made. There have also been two short periods of apparent excess energy, although these did not exceed 20% of the energy input or last more than a few hours.

These observations have not been reproduced and do not confirm the claimed cold fusion effects. However, the apparent unusual phenomena are interesting and will be the basis for additional investigation. The next system will utilize a continuously flowing electrolyte solution that is the heat exchange media and in situ recombination of evolved D_2 and O_2.

3. E. L. Fuller et al.

Six cells have been in operation for periods of one to three weeks. The electrolyte is 0.1 M LiOD, and the rod cathodes (five Pd, one Ti) have diameters of 6.4 mm to 10 mm. A variety of metallurgical pretreatments has been used, including cold casting, hot casting, and annealing. The cells are run at current densities which are varied in the range of 40 mA/cm^2 to 300 mA/cm^2 to see if non-equilibrium conditions trigger any unusual events.

Neutron detection, using one BF_3 counter to monitor the cells and one to monitor the background, has been used. No significant emission from the cells has been seen with this system, corresponding to a upper limit of 10^{-21} to 10^{-22} fusions/sec/deuterium pair. Analysis of cathodes for ^{4}He has failed to show anything above the detection limit (~10^9 He atoms) as has analysis of the off-gasses.

Apparatus is now set up for calorimetry, with an anticipated accuracy $\approx$1%. Calibrations are under way.

Extensive analysis of one previously-loaded cathode has showed interesting property changes (hardness, fractures, blistering, etc.). Additional studies are under way to evaluate the chemical and physical transformations for any possible contributions to energy balance.

4. J. G. Blencoe et al.

Experiments are in progress on the Pd-D_2 and Ti-D_2 systems at 50-350 MPa, 77-300 K to look for "cold fusion" in deuterides formed by pressurization with D_2 gas. The apparatus used is a 3/16" i.d. x 9/16" o.d. x 12" stainless steel pressure vessel that can be operated routinely at pressures as high as 400 MPa.

Diagnostics include (1) an array of three, 2" o.d. x 16", BF_3 neutron detectors immersed in a water bath with overall efficiency ~6%; (2) an internal, type-K sample thermocouple; and (3) an internal, type-K reference thermocouple located approximately 4" above the sample thermocouple. The neutron flux, D_2 pressure, sample and reference thermocouple readings, and bath temperature were recorded continuously at time intervals ranging from 6 seconds to 10 minutes.

Results obtained so far indicate no effect at the levels reported by Frascati and range from negative to ambiguous at the levels reported by Los Alamos. No sustained heat production has been observed in any experiment. Thermal pulses that persist briefly after pressurizing Pd with D_2 gas are attributable to small amounts of chemical heat released when Pd and D_2 react to form Pd deuteride. No sustained neutron flux above background was observed in any Pd-D_2 experiment. Two separate periods of apparent enhanced (≈10%) neutron flux have been recorded in a single Ti-D_2 experiment; however, additional experiments, including continuous background monitoring, are needed to obtain meaningful data at these levels.

Battelle
Pacific Northwest Laboratories
P.O. Box 999
Richland, Washington U.S.A. 99352
Telephone (509) 376-2261

Telex 15-2874
Facsimile (509) 375-2718

June 15, 1989

Dr. David Goodwin
Special Assistant to the
Associate Director
Office of High Energy Nuclear Physics
ER-20.1, GTN
U.S. Department of Energy
Washington, DC 20585

Reference: Letter, June 5, 1989, William L. Woodard to Dr. William R. Wiley.

Dear Dr. Goodwin:

Subject: Summary of PNL Cold Fusion Research Activities

Enclosed is a summary of PNL's research activities in cold fusion as per Dr. Woodward's request dated June 5, 1989. This summary covers our research activities as of March 23, 1989, and includes our current experimental activity and collaborations.

Our current level of activity includes 6 scientists/engineers working at about a 2 manyear/yr. level of effort. We're pleased to participate with other DOE laboratories in assessing cold fusion phenomena. If you need further technical information, please contact Dr. Russell H. Jones at (509) 376-4276.

Very truly yours,

WR Wiley

W. R. Wiley
Director

WRW:sw

cc: PM Pak - DOE-RL
JJ Sutey - DOE-RL
WL Woodard

Attachments

RESEARCH ON "COLD FUSION" PHENOMENA AT PACIFIC NORTHWEST LABORATORY

R. H. Jones, R. P. Allen, R. L. Brodzinski, M. D. Merz,
J. R. Morrey, L. L. Nichols, K. H. Pool and J. F. Wacker
Pacific Northwest Laboratory
Richland, Washington 99352

Research on cold fusion has been in progress at PNL since the March 23, 1989 announcement by Pons and Fleischmann. Early experiments emphasized nuclear counting for neutrons, gammas and x-ray. Experimental changes were made as more information regarding the conditions used by Pons and Fleischmann became available. An integrated experiment to measure heat and nuclear products in closed electrolysis cells is in progress. Other activities include a gas charging experiment and collaboration with Texas A&M and the University of Utah in tritium measurement of their D_2O.

SUMMARY OF PHASE I EXPERIMENTS

Experiments have been run to verify the claim of Pons-Fleischmann that "cold" fusion occurs in the Pd-deuterium system. Pd cathodes were electrochemically charged with deuterium from a 0.1M LiOD electrolyte. The Pd was 99.9% pure and consisted of 3 to 5 mm wide strips cut from a 25 by 25 mm wide by 1 mm thick foil piece. A Pt lead was spot-welded onto each Pd strip. Pt wire (0.68mm diameter) was used as the anode in most experiments. The LiOD solution was made by dissolving either ^7Li metal or $^6Li_2O$ in 99.8% D_2O. Cells were run at constant current, with current densities on the Pd ranging from 16 to 320 mA/cm^2, both cell voltages and currents were periodically measured, however, no temperature measurements were made. In one experimental setup, an electrochemical cell was placed inside a high sensitivity neutron counter and neutron counts were taken at 10 min intervals. In addition, temporal multiplicity events, characteristic of bursts postulated to be produced by muon catalysis, were measured by connecting the output of the neutron counter to a multiplicity counter. In a second setup, a cell was placed inside a germanium gamma-ray spectrometer to measure Pd x-rays generated by high energy fusion products (e.g., protons) and secondary gammas produced by (n,γ) reactions on a Cd foil placed around the electrolysis cell. Gamma-ray spectra were collected over 1 to 2 day intervals.

Approximately 13 experiments were run, with the longest continuous charging time being 20 days. No positive results have been observed; upper limits to the D-D fusion reaction rate are $\sim 2 \times 10^{-21}$ and $\sim 3 \times 10^{-18}$ fusions/sec per D-D pair for neutron and x-ray measurements, respectively.

SUMMARY OF INTEGRATED EXPERIMENT

Several pertinent factors became apparent following our early experiments. These factors are: 1) the need to perform the calorimetric experiments in a closed system, 2) the observation of high tritium in the Texas A&M cells and 3) the difficulty of obtaining D/Pd ratios greater than about 0.8. Therefore, an integrated experiment in which nuclear products and heat are assessed in a closed system was undertaken. Also, an emphasis is being placed on obtaining a D/Pd ratio greater than 0.8.

Internal D_2 and O_2 recombiners will be used to maintain a closed system. These cells will use 5 mm diameter by 5 cm long Pd rods which have been arc-melted and annealed at 1000°C in D_2 gas. Internal cooling coils will be used to maintain isothermal conditions and the temperature difference of the inlet and outlet coolant used to calculate the heat output of the cells. The input heat will be determined from the integrated electrical energy input to the cells. Since the cells are closed, all energy associated with D_2 and O_2 production is returned to the cells. The data is continuously monitored with data logging system and D_2O will be removed periodically for tritium analysis. ^3He and ^4He analysis will be conducted on the Pd rods following the experiments. Neutron and gamma counting will be conducted. Goals for this research are twofold: 1) measure the tritium concentration in the D_2O of a closed electrolysis cell and correlate these results with thermal and neutron/gamma measurements and 2) to evaluate the same parameters in an electrochemical cell with a D/Pd ratio >1. Recombination poisons and other surface alterations will be used to maximize the D/Pd ratio.

SUMMARY OF OTHER ACTIVITIES

PNL has conducted one gas charging experiment similar to those conducted at Frascati and at LANL. A palladium rod was heated while inside a high pressure gas cell filled with deuterium gas. The cell was then counted using a moderated BF_3 tube neutron detector which had been calibrated with an NBS traceable PuBe neutron source. The cell was cooled to liquid nitrogen temperature and allowed to slowly warm back up to room temperature while neutron counts were taken. Each count lasted 10 minutes, and data were recorded for about 70 hours. No neutrons above the background level were detected coming from the gas cell.

PNL's tritium analysis capabilities have been made available to other laboratories. Tritium analysis has been performed on D_2O obtained from Bockris' group at Texas A&M and from Milt Wadsworth at the University of Utah. Our results from the Texas A&M samples are as follows:

Sample	dpm/ml
Electrolysis Cell	1.96×10^6
Electrolysis Cell	1.17×10^3
Blank-D_2O	140
Blank-D_2O+0.1MLiOD	127
Standard	8.08×10^5

We recently analyzed the D_2O from a cell operated by Professor M. Wadsworth at the University of Utah. This cell operated for several days at an increased temperature following a significant temperature increase which lasted a short period. Tritium analysis was performed on the starting electrolyte and samples removed immediately following the large temperature rise and after the cell operated at the elevated output for several days. A small increase in tritium was noted for the electrolysis samples relative to the blank, but the increase was only about 36% which is within that expected from the difference in electrolysis of D_2O and T_2O.

PNL has been approached by the University of Utah to assist them in the analysis of palladium electrodes from several Pons and Fleischmann electrolysis cells. Our role will be to act as an intermediary between the University of Utah and laboratories performing the analysis. We have also offered to perform surface, microstructural and chemical analysis of the electrodes.

PRINCETON PLASMA PHYSICS LABORATORY

Date: June 15, 1989

To: Energy Research Advisory Board
US DOE 1000 Independence Ave., SW
Washington, DC, 20585

Subject: Summary Report of PPPL Cold Fusion Experiments to the ERAB, pursuant to W. L. Woodard to H. F. Furth, 5 June 1989, pursuant to Watkins to Schoettler, 24 April 1989

Filed by: D. M. Manos, Head, PPPL Ad-hoc Task Group on Cold Fusion

Motivated by press releases on cold fusion, PPPL, in association with Electron Transfer Technologies, Inc. of Princeton, NJ, undertook a modest experimental program to investigate certain claims. At PPPL, two apparatus were set up, one to count neutrons, one to count gamma rays.

APPARATUS

A schematic drawing of the neutron counting apparatus is shown in Figure 1 and a block diagram of the counting circuitry employed for this apparatus is shown in Figure 2. Not shown in Figure 1 is an interior lid of cadmium absorber material which was present on top of the inner steel drum. The apparatus is capable of displaying the neutron energy spectrum in addition to the counts which fall within a selected range of energies accumulated during adjustable periods of time. The range was adjusted so that only events corresponding to the deposition of 2 to 3 MeV in the BF_3 detectors would register on the counter. The device was calibrated frequently using a ^{252}Cf source. The background neutron rate was highly variable, ranging from 3 to 30 counts/hr. The neutron efficiency was 2% for experiments using the central test cell, 0.3% for most experiments using the outer test cell, and 0.1% for certain few experiments which used the outer test cell and a modified arrangement of shielding materials. Figure 3 shows a comparison of a background spectrum and the spectrum of the ^{252}Cf source. We claim that our apparatus can continuously resolve a neutron source strength of 1 n/s.

Figure 4 shows a schematic, including a block diagram of the counting equipment, for the gamma ray counting apparatus. The counter, borrowed from the Colorado school of Mines, consists of a 4" dia. by 4" long, cylindrical NaI crystal, surrounded by a 4 inch i.d. , 12" o.d. by 8" long, annular NaI crystal. The interior crystal is fitted with a single photomultiplier, the annular crystal is fitted with 6 photomultipliers. The geometric arrangement is shown in Figure 4. When a gamma ray transits the annular NaI crystal the resulting signal from one of the 6 outer photomultipliers is used to gate the counting electronics so as not to count the signal from the interior photomultiplier should that gamma ray also transit the interior crystal. This provides a very effective discrimination against the cosmic ray background. This apparatus also permits display of the energy spectrum aong with the total counts within a selected energy range during an adjustable counting time interval. The energy range selected was 5-6 MeV, in an attempt to observe the 5.4 MeV gamma production associated with the p-D fusion reaction. The detection efficiency for the apparatus is 0.3 %. The observed background count rate with the anti-coincidence veto active was 10 to 25 counts/hr., the background with the veto off was 275 counts/hr. Figure 5 compares of backgrounds with the veto on and off, indicating the observed spectrum in our laboratory, and showing the selected energy window. We claim that this apparatus can continuously resolve a gamma source strength of 1.5 photons/s.

EXPERIMENTS

Using these counting apparatus we studied the following different types of "cold fusion" systems:

1. Electrochemical cell using Pd rods and spheres, metallurgically prepared both by casting and drawing using LiOD in D2O at current densities up to 0.6 amps/cm^2. A similar cell was studied at Electron Transfer Technologies to determine whether energy and power balance were achieved.

2. Electrochemical reactor using Pd wires and spheres, metallurgically prepared by casting and drawing using LiOH in 50% H2O/50% D2O. (In addition to the D-D reaction, the p-D reaction was chosen for careful study to test the hypothesis that fusion may occur by tunnelling through a coulomb barrier at low temperature, mediated by unknown effects from the crystal lattice. Such studies are made easier by the relatively rare occurrence of 5.4 MeV events in the cosmic ray background.)

3. Thermal and pressure cycling of Ti turnings as prescribed by workers at Frascati.

4. Thermal and pressure cycling of ultra-pure, 200 mesh Ti powder as prescribed by workers at Genoa.

5). Numerous variations of items 3 and 4 changing the schedule of variation of pressure and temperture with time.

6. Thermal and pressure cycling of Nb bar stock and Nb turnings using the pressure and temperature schedule of Frascati.

7. Thermal and pressure cycling of alumina, quartz, and feldspar mixtures (known to have large piezoelectric coefficients and/or to produce persistent high-energy exo-electron emission on fracture).

8). Tensile and compressive strain and fracture of Ti sheets loaded with D2 by glow discharge plasma bombardment.

9. Rapid compressive fracture (hammer blows) of Zr/Al/V pellets loaded with D2 by glow discharge plasma bombardment (after the method of Klyuev et al).

RESULTS

In every case we saw no neutrons or gamma rays above the measured background, as indicated in the following table:

Experiment	**Claimed Level**	**Observed at PPL**
Electrolysis D-D	4×10^4 n/sec	< 1 n/s
Electrolysis p-D	>4×10^4 photons/s Theoretical	< 3 photons/s
Pressure/Temperature Cycling (Frascati, Genoa)	5×10^3 n/s	< 1 n/s
Fracture studies	3 × background	no change from
(Klyuev and variants)	(0.4 n/shot)	background
Jones et al	0.4 n/s	not attempted

(special electrolyte)In the electrolytic cell experiments at Electron Transfer Technologies, performed by William Ayres, we found energy and power balance to within +/- 10% for currents up to 0.6 amps/cm^2. The uncertainties at low currents make the error bars larger than at high current. Figure 6 summarizes our energy balance experiments.

PRESENT STATUS

Based on our own results and those reported by other groups we feel that the proof of the existence of cold fusion now requires unequivocal demonstration to qualified observers by those who claim to be able to detect it. Therefore we have reduced our level of activity in this area.

We have returned the gamma ray detector to Colorado School of Mines and have suspended indefinitely, work on electrochemical cells. We have suspended attempts to reproduce pressure and thermal cycling results of the type claimed by Frascati and Genoa pending further reports from the group of Menlove et al, at Los Alamos. We are sustaining a low-priority effort related to further studies of X-rays, radio waves, and neutrons which may result from particle acceleration in electric fields associated with the fracture of deuterium-loaded non-conductors and metals. We intend these studies to be conducted in the surface physics branch by an incoming graduate student.

cc: E. C. Brolin
H. F. Furth
L. Ianello, DoE
D. Meade
Members Ad-Hoc Cold-Fusion Group
PPPL Division Heads

#89X0302

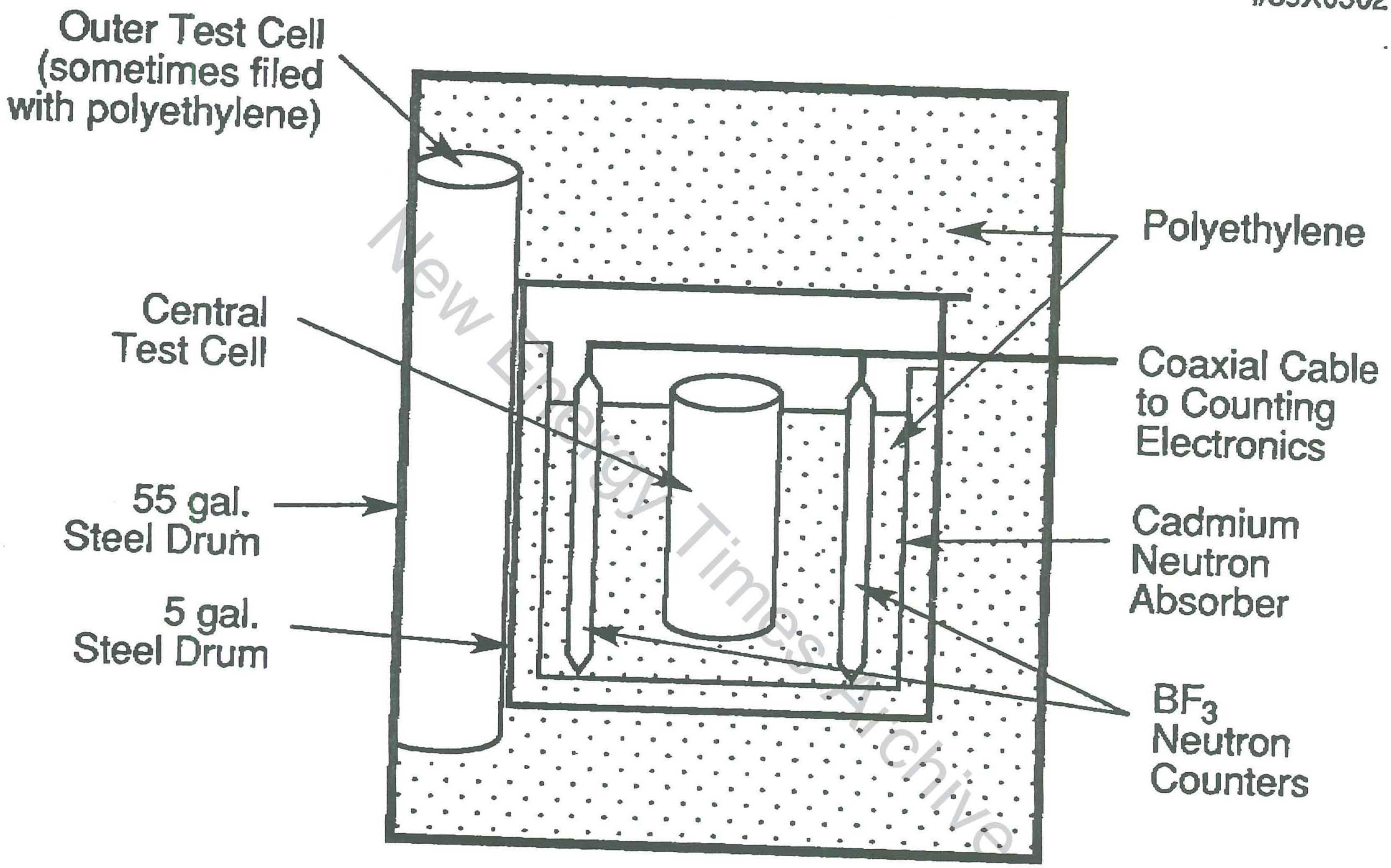


Figure 1

#89X0303

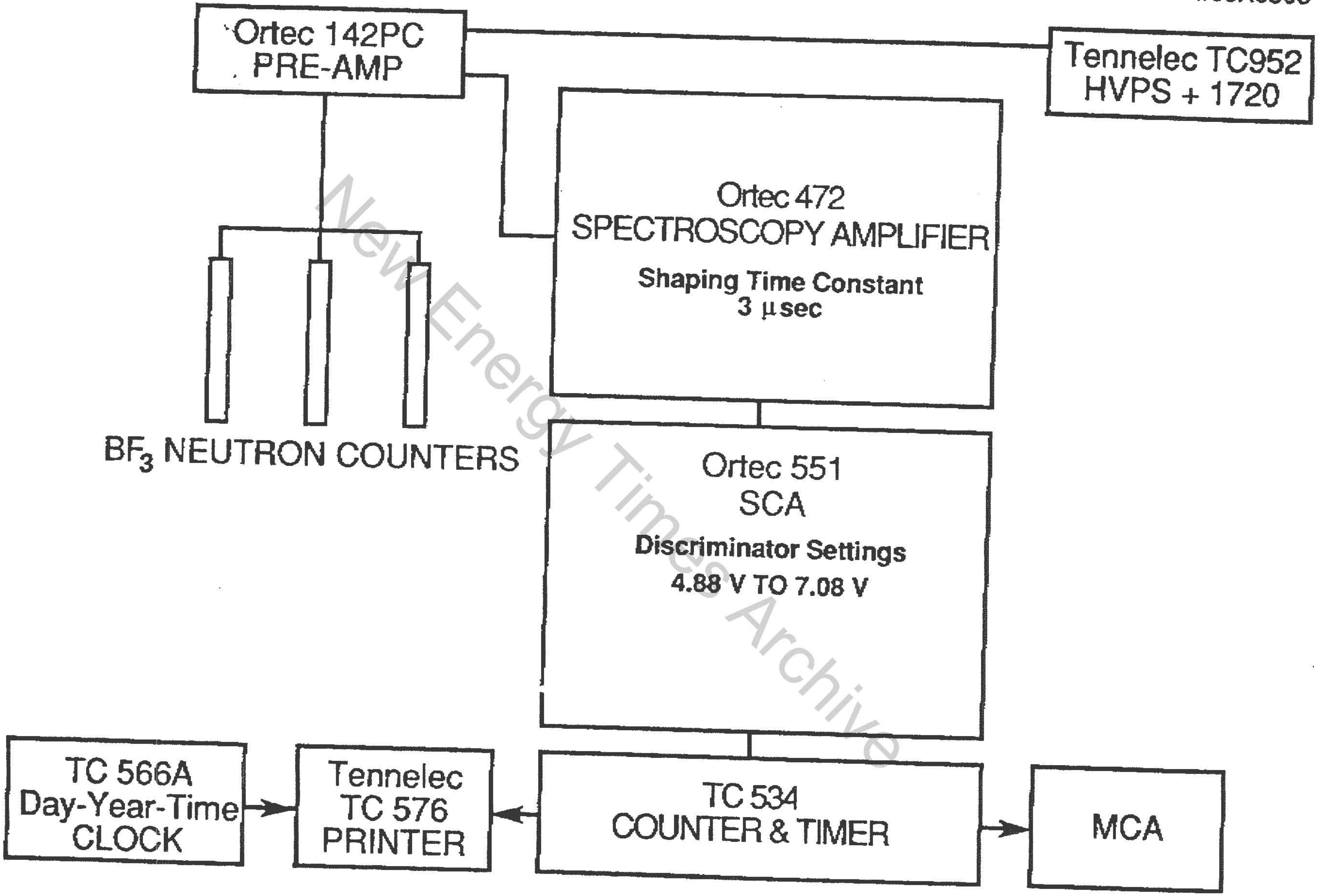


Figure 2

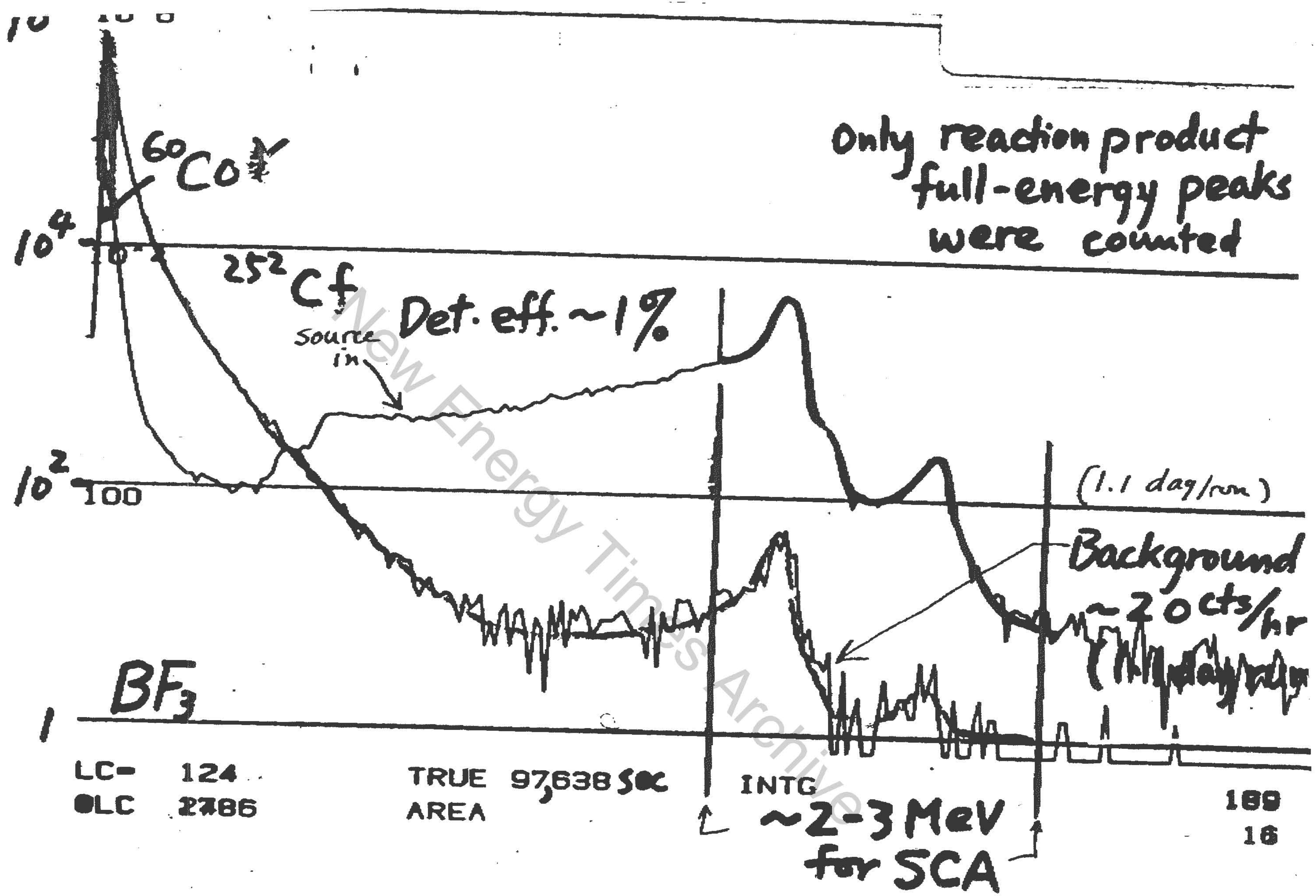

10
10
10⁴
10²
100
1
⁶⁰Co
²⁵²Cf
Source in
Det. eff. ~1%
Only reaction product full-energy peaks were counted
(1.1 day/run)
Background ~20 cts/hr
(1.1 day/run)
BF₃
LC= 124
●LC 2786
TRUE 97,638 sec
AREA
INTG
~2-3 MeV for SCA
189
16

Figure 3

#89X0308

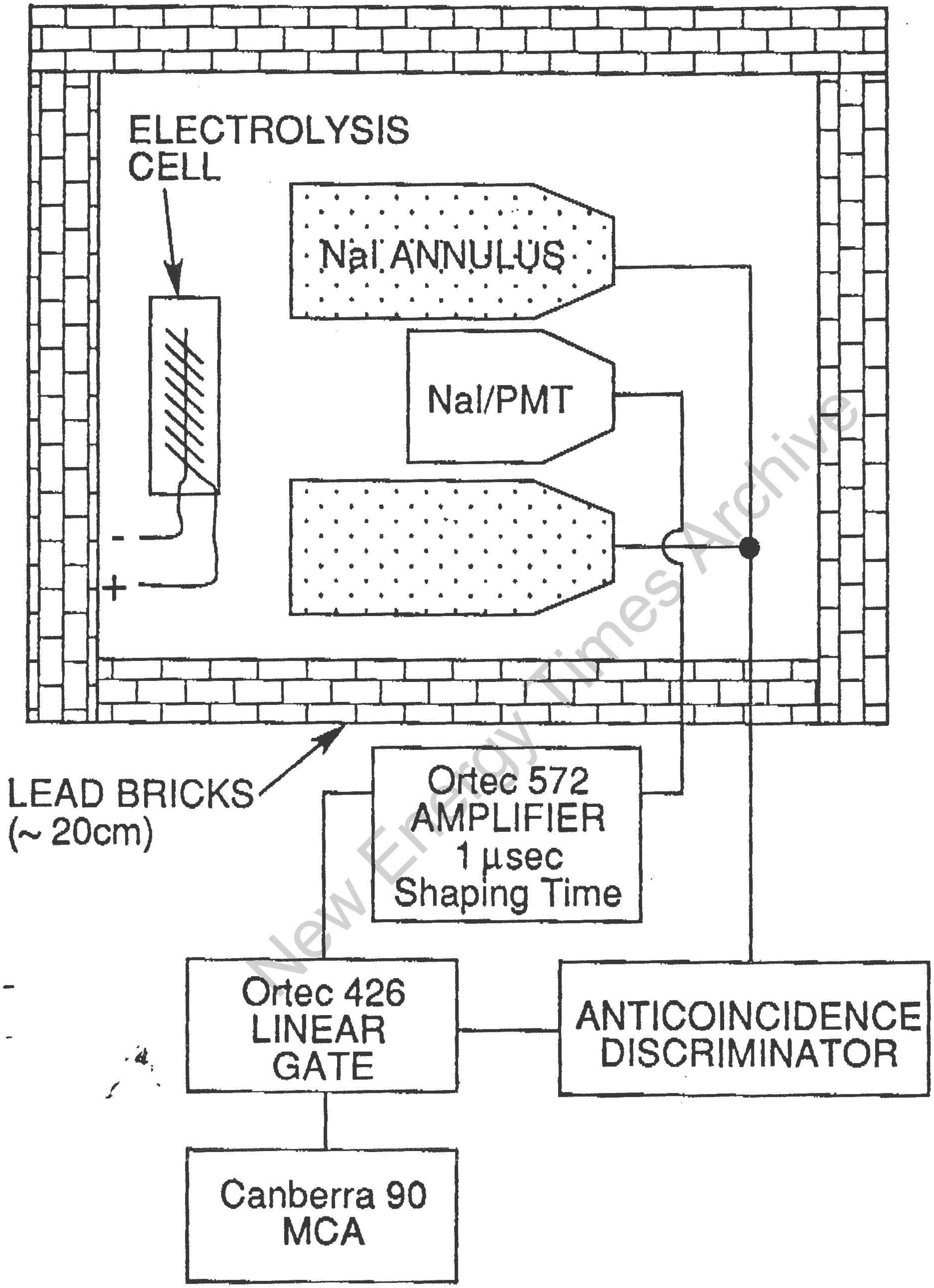


Figure 4

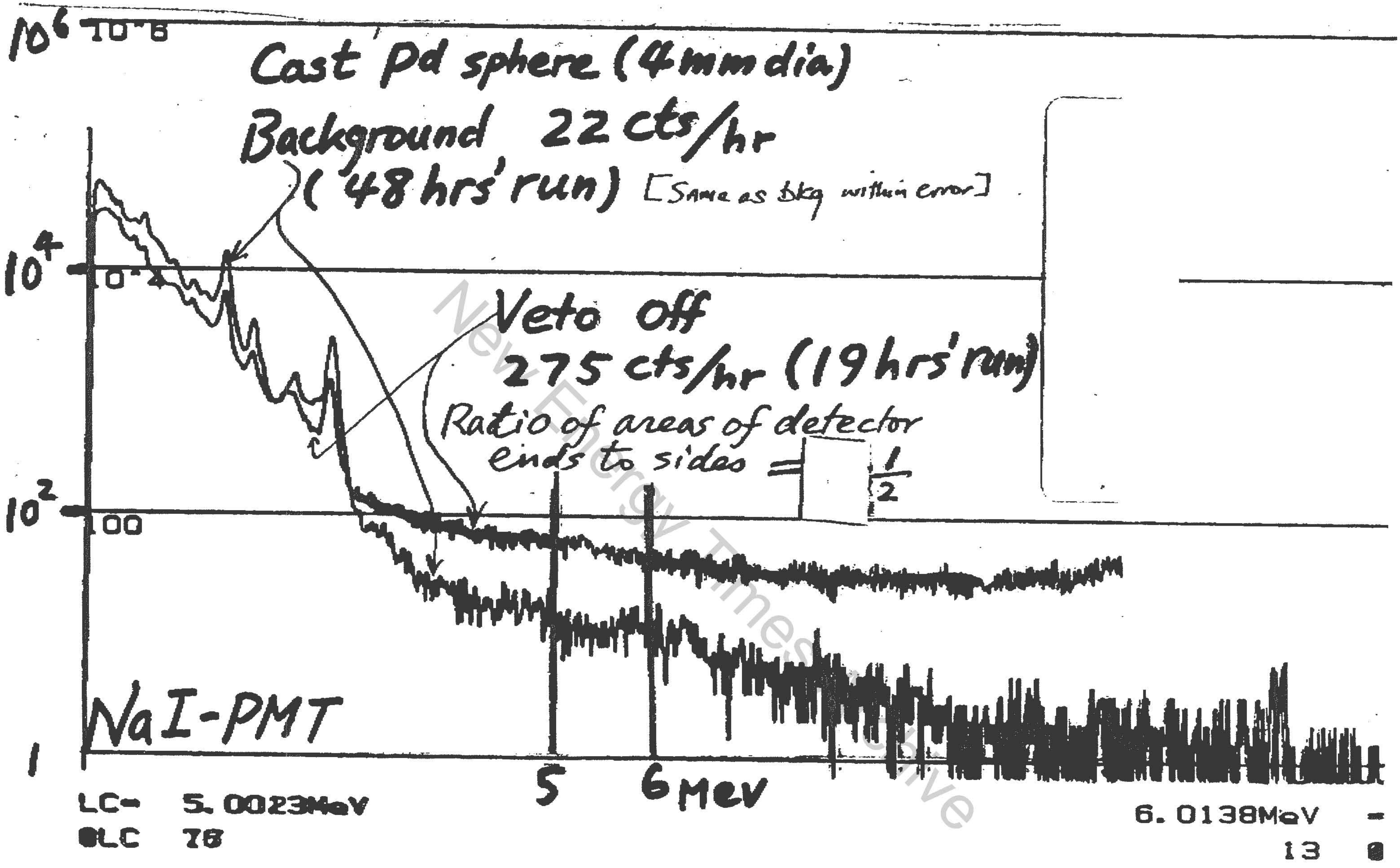

10^6
10^6
Cast Pd sphere (4mm dia)
Background 22 cts/hr
(48 hrs' run) [Same as bkg within error]
10^4
10^4
Veto off
275 cts/hr (19 hrs' run)
Ratio of areas of detector ends to sides = 1/2
10^2
100
NaI-PMT
1
5
6 MeV
LC= 5.0023MeV
●LC 78
6.0138MeV
13

Figure 5

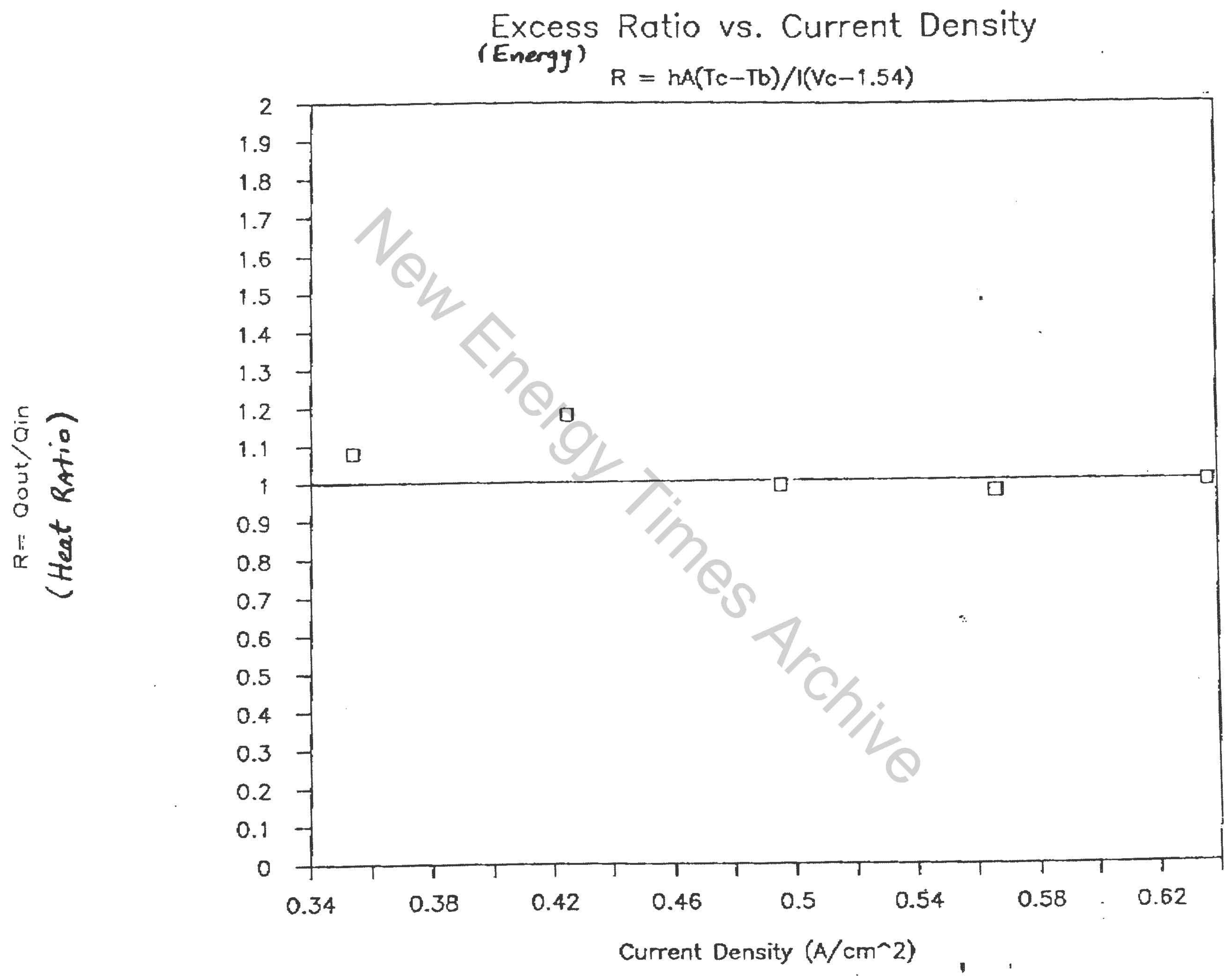

Excess Ratio vs. Current Density
(Energy)
R = hA(Tc–Tb)/I(Vc–1.54)
R= Qout/Qin
(Heat Ratio)
2
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0.34
0.38
0.42
0.46
0.5
0.54
0.58
0.62
Current Density (A/cm^2)

Figure 6

SUMMARY OF COLD FUSION RESEARCH PROGRAM
Sandia National Laboratories
June 15, 1989

I. OVERVIEW

Since the announcement of cold fusion in late March by the University of Utah investigators we have carried out an extensive range of research activities at Sandia National Laboratories in an attempt to duplicate those experiments and also to gain evidence for the existence of this phenomenon. The program has focused on experiments of both the University of Utah type, where significant excess heat was reported, and on the Brigham Young University type, where a lower level of fusion reaction was reported. Approximately twenty members of technical staff have been involved, representing expertise in materials science, radiation physics, electrochemistry, solid state physics and metallurgy. We find no evidence for the existence of cold fusion. Remaining investigations are focused on our sensitive calorimetry experiment to search for the production of excess heat at longer operating times.

II. DETECTION SYSTEMS

Three special detection capabilities have been utilized in these studies. First we have set up a multi-detector neutron detection system of ^{3}He proportional counters and located it underground on Kirtland Air Force Base near our Albuquerque location. This has allowed us to carry out studies with both electrochemical cells and high pressure gas cells with the capability of detecting continuous neutron emissions corresponding to production levels as low as 100 neutrons/hr or bursts as low as 50 neutrons. Not only have these underground experiments allowed us to reduce background levels by three orders of magnitude from aboveground tests, but by correlating the signals from three independent detectors operating simultaneously we have found that we are able to essentially eliminate spurious artifacts which occasionally give false signals in one detector system but not in all three simultaneously. Single-detector artifacts were observed that closely mimic both continuous and burst emissions reported previously as being due to cold fusion.

A second special capability is a closed cycle Freon calorimeter system in which we are performing electrochemical cell experiments. This calorimeter has the advantage of being sensitive to the presence of small amounts of excess heat at high power levels (e.g., 1% at 20 W). Also, the total energy input is monitored from initiation of the experiment. We are presently conducting experiments with palladium electrode volumes >0.8 cm^3 and current densities above 300 mA/cm^2, while taking into account all experimental details proposed to be important by Pons and Fleischmann and by Huggins, but with a much more sensitive and accurate calorimetry system.

Finally we have utilized sensitive charged particle detection in conjunction with thin (25 μm) Pd foils where the foil forms one wall of the electrochemical cell. This approach allows the t+p branch of the D-D fusion reaction to be detected with essentially no background at very large detection efficiencies. The above three detection approaches have allowed us to exceed the sensitivity of the U. of Utah and the BYU experiments.

III. COLD FUSION EXPERIMENTS

A. Electrochemical Cells—(1) U. of Utah of Type: Electrochemical cells designed after the Pons and Fleischmann experiment have been carried out using a wide variety of electrode preparations, size, current densities, and times (up to 45 days). We have searched for the presence of radiation using neutron detectors, tritium by analyzing the electrolyte, and excess heat with our sensitive calorimetry system. We feel these experiments require another 10 to 15 days to exclude the possibility of excess heat generation, since our sensitive calorimetry under large sample volumes and high current densities has only been in operation for about two weeks. (2) BYU Type: Electrochemical cell experiments of the type reported by Jones et al. have been conducted using a wide variety of electrodes including Ti and Pd, immersed in LiOD or the Jones "mother earth" electrolytes. These were carried out under normal laboratory conditions as well as at the high neutron sensitivity underground location. (3) Thin Wall Cell Type: We have also utilized our thin wall cell configuration to obtain an order of magnitude higher sensitivity than in the Jones experiment (for bulk reaction rates within the Pd thin foils). These studies, as well as those of the BYU type, have been carried out for both steady-state and pulsed charging modes to look for cold fusion under highly non-equilibrium conditions.

B. Pressure/Temperature Cycling—We have carried out a wide variety of experiments in which pressure and temperature have been cycled between 1 atm and 4 kbar and between room temperature and 77 K. Materials included Pd powder, Ti powder, sintered Pd-Ti powder of the prescription given by Jones, TiD$_2$, Ti electrodes soaked in Jones electrolyte, and TiV and Zr shavings. The sensitive underground neutron detection system was used.

C. Plasma Loading—We have conducted experiments in which the atomic deuterium was introduced into Pd powder by plasma loading and the radiation measured by neutron and charged particle detectors. Experiments focused on understanding conditions for minimizing surface recombination and allowed loading ratios of about 0.9 D-Pd to be obtained.

D. Implantation Loading—Direct deuterium ion implantation into Pd and Zr at low substrate temperatures (40 K) were carried out to achieve superstoichiometric conditions. In the case of Pd, for example, we achieved loading ratios of D/Pd $\approx$1.6, with charged particle detectors used to monitor the t+p branch of the cold fusion reaction.

E. Chemical Assays for Fusion Products—We collaborated with Rockwell International (Canoga Park, CA, 91303) in the search for evidence of ^{3}He or ^{4}He fusion products in Pd electrodes from electrochemical cells provided by a number of U.S. laboratories. Measurements at Rockwell's Helium Assay Facility involve vaporizing samples under vacuum, passing all gases through multiple getter stages and measuring the helium concentrations using a precision mass spectrometer that had been calibrated with Pd samples implanted at various ^{4}He fluences by Sandia. The ultimate detection level is $\sim 1 \times 10^{10}$ helium (^{3}He or ^{4}He) atoms per gram of Pd and in no case (including samples from Texas A&M that were reported to exhibit either excess heat, neutron or tritium production) was there any helium product (^{3}He or ^{4}He) detected above system background.

In all the above experiments we were unable to find evidence for the presence of any radiation, radiation products, or excess heat which would have indicated the presence of cold fusion. We believe that we have faithfully reproduced the experimental conditions as best known and have a greater sensitivity for the presence of the phenomenon than that reported by the original investigators.

IV. SUPPORTING STUDIES

A. Loading Kinetics of Electrochemical Cells—Two experiments were conducted to better understand the actual loading kinetics of Pd electrodes, since it has been speculated that high D-to-metal loading ratios are important and there have been questions as to the loading times, cell operating conditions and electrolyte conditions under which proper loading may be achieved. In the first experiments thin wall cells were utilized in conjunction with an external ion beam for direct in situ analysis of the D concentration within the Pd metal. Loading dynamics as well as D/H poisoning kinetics were examined. In the second set of experiments the permeation through electrochemical cell thin foils examined the influence of palladium electrode surface preparation on the loading achieved.

B. Deuterium Atom Spacing—Molecular dynamics and total energy band structure calculations were carried out to examine the minimum D-D spacings which would be expected to be achieved. Theoretical consideration was also given to possible closer spacings on the surface of Pd. Even for superstoichiometric D:Pd ratios no evidence for D-D spacings closer than that for the D_2 molecule (about 0.7 Å) was found under the most favorable model conditions, and in all of these studies no evidence was found to predict a sufficiently close spacing as required by the proposed rates for cold fusion.

C. Power Balance Calculations—The assertion by Profs. Fleischmann and Pons of excess energy production is derived from a power balance calculation based ultimately on Newton's Law of Cooling which may not be directly applicable in their situation. They use a submerged resistor to heat the electrolyte solution and assume a constant heat transfer coefficient which in turn is used to calculate the energy loss rate, $k_T \Delta T$, to the surrounding environment. However, total heat loss (especially from evacuated Dewar cells) may be dominated by evaporation of electrolyte which increases exponentially with temperature. Calculations under the assumption of evaporation-dominated heat loss suggest that there is, in actuality, little or no excess energy produced.

V. SUMMARY

In summary we have investigated electrochemical loading, pressure and temperature cycling, and the direct formation of superstoichiometric metal hydrides by implantation for the production of cold fusion. We have found new ways to probe the kinetics of hydrogen isotope loading of electrochemical cells and we anticipate that these may bring research benefits outside cold fusion. We have carried out detailed neutron detection at extremely low rates underground with unexpected spurious continuous and burst signals in helium-3 detectors not previously appreciated. We find multiple detectors provide an excellent way to exclude spurious signals which might otherwise be interpreted as evidence for cold fusion. Finally, we find no evidence to support the existence of cold fusion in any of our studies or to suggest the appropriateness of initiating an extensive program of research in this area.

SANTA FE WORKSHOP SUMMARY

HEAT

ALSO ROME: 200 JOULES/4 MIN.

ALSO NO HEAT: MIT, NAVY, MISSIOURI, SAVANNAH
RIVER, et. al

NEUTRONS

ALSO: BOLOGNA: NEARLY 5 X BACKGROUND
ROME : 150 TIMES BACKGROUND BURST
(36/4min.)

ALSO NO NEUTRONS: MIT, AT&T, PRINCETON, BERKELEY, SAVANNAH RIVER, et. al

GAMMAS

ALSO NO GAMMAS: MIT, PRINCETON, SAVANNAH RIVER, et. al

CHARGED PARTICLES

- o CECIL: 4 SIGMA
- o ALSO NO CHARGED PARTICLES: BERKELEY (2 GROUPS), NAVY (FALSE POSTIVES), MISSOURI, et.al

D2 GAS

ALSO: ENEA, ITALY (NEUTRON BURSTS)

ALSO: PRINCETON (NO NEUTRONS, NO GAMMAS),
BERKELEY (NO He-3), et.al

OTHER

STUDIES OF PROPERTIES

MUON CATALYSED

PLASMA CHARGING

THEORY

FUSION RATES

ROUGH DRAFT

CAVEAT EMPTOR

Attached are tables and plots summarizing a database created by LANL staff during the Santa Fe Workshop on Cold Fusion Phenomena. This data was entered in a short time with almost no direct input from the authors. Primary sources were abstracts, oral presentations, and posters. As complete input data was not always available, and as the diverse measurements did not easily submit to tabulation, the present exercise should be regarded as an attempt to create a global picture, and not a detailed accounting. Please do not circulate these tables and plots widely.

This tabulation includes work for all abstracts submitted, including no-show posters. Some work may be represented twice if the same group submitted more than one abstract.

We have tried to tabulate final results in units of fusions/pair/second, when possible, in order to allow a comparison of experiments. In some cases we have calculated this number ourselves from limited input. The numbers should be regarded as uncertain to one or two orders of magnitude. It was assumed that an effect would be proportional to the volume of the host, and not to the surface area.

Here are a few explanatory notes. Some tables have two columns "meas. effect" and "upper limit." The same result is entered: entry in the first indicates a finite result obtained; entry in the second, an upper limit as given. Under category, ELECTROL means electrolysis, and SS means solid state. On the theory tabulation, CHEM means chemistry, TUN means tunneling, and PLAS EFF is short for plasma effects. For the plots, only data for which the fusions/pair/sec were extracted is shown. No calorimetry data is plotted. The rate is in units of fusions/pair/sec. (The finite results are those of Jones, Bertin, Wolf, and Cecil). In the final plot, the calorimetry value of Pons and Fleischmann, converted assuming normal nuclear branching ratios, would be at the top of the graph (-12).

I acknowledge my fellow sufferers in this task: Charlie Bowman, John Moses, Al Petchek, Steve Wender, Jordan Camp, Kathy Smith, and Lynn Maas, none of whom have yet looked at this version.

P. Dyer
6/19/89

MEASUREMENTS OF HEAT

1ST AUTHOR INSTITUTION	REACTION SOUGHT	CATEGORY	HOST MATERIALS	MEASUREMENT TECHNIQUE	HEAT OBSERVED?	EFFECT	RESULTS	COMMENTS
S.SRINIVASAN TEXAS A&M UNIVERSITY	d+d	ELECTROL	PD AND PT WIRE	MICROCALORIMETRY	Y	19 W/ML PD	EXCESS HEAT GENERATED FOR D20 IN 0.1 M LiOD ON PD CATHODE, BUT NOT IF CATHODE PT AND NOT IF 0.1 M LiOH; 0.1 M NaOD USUALLY NORMAL Li BUT ALSO 7Li+0.2%6Li RESOLUTION 1 MICROW IN 8 WATTS. MEASURES HEAT FLUX COUNTING TEN	MICROCALORIMETER MEASUREMENT; RESOLUTION 1 MICROWATT IN 8 WATTS
G.A.WURDEN MAX PLANCK INSTITUT FUR PLASMA PHYSIK	d+d	ELECTROL	Pd, CAST	CALORIMETRY	N		NO NEUTRONS, TRITIUM OR GAMMAS OBSERVED; NO EXCESS HEATING OBSERVED	LOADED Pd SAMPLE COOLED IN LN2; NO NEUTRONS OBSERVED
R.CROOKS MASSACHUSETTS INSTITUTE OF TECHNOLOGY	d+d	ELECTROL	Pd ROD	CALORIMETRY	N		NO NEUTRONS, GAMMA RAYS, HEAT, TRITIUM, OR HELIUM-4 DETECTED	GAS BUBBLED THROUGH BUBBLER, H20 VS D20 AGREE TO 9%
N.S.LEWIS CALIFORNIA INSTITUTE OF TECHNOLOGY	d+d	ELECTROL	Pd, VAR FORMS	CALORIMETRY	N		NO NEUTRONS, GAMMA RAYS, TRITIUM, OR HEAT OBSERVED	SOME Pd 5 9'S PURITY
J.G.BLENCOE OAK RIDGE NATIONAL LABORATORY	d+d	SS	Pd AND Ti	THERMOCOUPLE MEASUREMENTS	N		NO NEUTRON OR HEAT PRODUCTION MEASURED	PURPOSE: INVESTIGATE WHETHER ELECTROLYSIS NECESSARY; SEE HEAT, PROBABLY FROM DEUTERIDE FORMATION OR GAS CONDENSATION

WARNING
data not verified by authors

1ST AUTHOR INSTITUTION	REACTION SOUGHT	CATEGORY	HOST MATERIALS	MEASUREMENT TECHNIQUE	HEAT OBSERVED?	EFFECT	RESULTS	COMMENTS
M.E.HAYDEN UNIVERSITY OF BRITISH COLUMBIA	d+d	ELECTROL	Pd BARS	CALORIMETRY	N		NO EXCESS HEAT GENERATION TO 0.3% LEVEL FOR INPUT POWERS IN THE 4 TO 18 WATT RANGE	CALORIMETER WAS SELF-SUSTAINED CATALYTIC RECOMBINATION OF EVOLVED GASES; OPERATES IN CLOSED FASHION; THERE WAS ARGUMENT WITH TEXAS A&M ABOUT VAPOR LOSSES
A.BELZNER STANFORD UNIVERSITY	d+d	ELECTROL	Pd	CALORIMETRY	Y		D20 GIVES EXCESS HEAT, H20 DOES NOT	TALK ABOUT METALLURGY OF Pd-D, NOT ABOUT COLD FUSION, BUT SOME EXPERIMENT
N.A.GODSHALL SANDIA NATIONAL LABORATORIES	D+D	ELECTROL	Pd	FREON VAPOR. CALORIMETER			NO DATA YET	SIMULTANEOUS MEASUREMENT OF HEAT & NEUTRONS; NO DATA YET; 0.1 W SENSITIVITY, CALORIMETER
L.REDEY ARGONNE NATIONAL LABORATORY	D+D	ELECTROL	Pd/WROUGHT /ANNEALED	CALORIMETRY	N		NO EXCESS HEAT DETECTED; < 0.13 WATTS	HEAVY WATER->93%, AFTER 8 DAYS DUE TO ATMOSPHERE
D.E.STILWELL NAVAL WEAPONS CENTER	D+D	ELECTROL	PT, Pd	CALORIMETRY	N		OBSERVATION OF EXCESS HEAT, MORE FOR D20 THAN H20; ATTRIBUTED TO RECOMBINATION OF GASES	

WARNING
data not verified by authors

1ST AUTHOR INSTITUTION	REACTION SOUGHT	CATEGORY	HOST MATERIALS	MEASUREMENT TECHNIQUE	HEAT OBSERVED?	EFFECT	RESULTS	COMMENTS
D.S.GINLEY SANDIA NATIONAL LABORATORIES	d+d	ELECTROL	Pd,Ti,Zr,V ,CeCu5	TEMP. MEAS.	N		NO NEUTRONS OR EXCESS HEAT OBSERVED	EXPERIMENTS DONE UNDERGROUND
S.GOTTESFIELD LOS ALAMOS NATIONAL LABORATORY	D+D	ELECTROL	Pd	TEMP.MEAS.	N		NO NEUTRONS OR EXCESS HEAT OBSERVED	USED GAMMA-RAY DETECTORS TO LOOK FOR NEUTRON CAPTURE; CALORIMETRY PLANNED
D.GOZZI UNIVERSITA' DI ROMA	D+D	ELECTROL	Pd	THERMOCOUPLE MEAS.	Y	200 JOULES/4MIN	AFTER 150 HOURS, BURST OF NEUTRONS 150 TIMES BACKGROUND OBSERVED SIMULTANEOUSLY WITH A SHARP INCREASE OF ELECTRODE TEMPERATURE AFTER 150 HOURS; TRITIUM OBSERVED:(8.5 +/- 1.5)*10^10 ATOMS	
S.R.LITTLE AUSTIN COLD FUSION	D+D	ELECTROL	Pd,Ti CAST	CALORIMETRY	N		NO NEUTRONS, GAMMA RAYS, OR EXCESS HEAT OBSERVED	
M.A.PRELAS UNIVERSITY OF MISSOURI-COLUMBIA	D+D	SS	Pd, Ti, Ni, Ta	CALORIMETER	N		COUNTS ABOVE BACKGROUND?	ATTEMPTS TO OBSERVE CF IN PLASMAS; CLAIM COUNTS ABOVE BACKGROUND; HEALTH PHYSICS MONITORS?

WARNING
data not verified by authors

page 3

1ST AUTHOR INSTITUTION	REACTION SOUGHT	CATEGORY	HOST MATERIALS	MEASUREMENT TECHNIQUE	HEAT OBSERVED?	EFFECT	RESULTS	COMMENTS
J.R.MORREY PACIFIC NORTHWEST LABORATORY	D+D	ELECTROL	Pd, ARC MELTED	TEMP.MEAS.			MEASURED HEAT, NEUTRONS, GAMMA RAYS; NO RESULTS REPORTED	
C.D.SCOTT OAK RIDGE NATIONAL LABORATORY	D+D	ELECTROL	Pd, CAST	THERMOCOUPLE MEAS.	N		NO HEAT OR GAMMA RAYS OBSERVED; SMALL INCREASE IN TRITIUM, PROBABLY EVAPORATIONS; NEUTRON BKG RATE FLUCTUATES, MAY BE SIGNIFICANT, 4 SIGMA AT ONE POINT	
H.W.RANDOLPH WESTINGHOUSE SAVANNAH RIVER COMPANY	D+D	ELECTROL	Pd	CALORIMETRY	N		NO HEAT, NEUTRONS, GAMMA RAYS OBSERVED	CAREFUL CALORIMETRY W/NULL RESULT. ELECTRODE LOADS IN HOUR; MEASURE BY REVERSING CURRENT; PRELIMINARY; SHORT RUNNING TIME. WILL CONTINUE; TRITIUM & HELIUM MEASURED?
P.A.SEEGER LOS ALAMOS NATIONAL LABORATORY	d+d	SS	Pd	UNKNOWN	(Y)		NO NEUTRONS CORRELATED WITH HEATING OBSERVED; MODEST HEATING ATTRIBUTED TO ELECTRICALLY DRIVEN CHEMICAL REACTION OF UNKNOWN ORIGIN	INJECTED ELECTRONS INTO DEUTERIUM--LOADED Pd, SO THAT THE ELECTRON CONCENTRATION IN THE METAL WOULD BE THE NON-EQUILIBRIUM STATE FOR A SHORT TIME
X.Y.WANG PEKING UNIVERSITY	d+d	ELECTROL, SS	Pd, Ti	TEMP.MEAS.			NO RESULTS	NO RESULTS PRESENTED FROM EITHER ELECTROLYSIS OR SOLID STATE

WARNING
data not verified by authors

1ST AUTHOR INSTITUTION	REACTION SOUGHT	CATEGORY	HOST MATERIALS	MEASUREMENT TECHNIQUE	HEAT OBSERVED?	EFFECT	RESULTS	COMMENTS
G.R.LONGHURST IDAHO NATIONAL ENGINEERING LABORATORY	d+d	ELECTROL	Pd FOIL & RODS	TEMP.MEAS.	N		NO NEUTRONS, GAMMA RAYS, TRITIUM OR EXCESS HEAT OBSERVED; TRITIUM < 1.E-6 MICRO CURIE/ML	EVALUATED NON-NUCLEAR HEAT PRODUCTION WITH CONCLUSION THAT UTAH EFFECTS COULD BE EXPLAINED BY NON-NUCLEAR PHENOMENA
J.E.SCHIRBER SANDIA NATIONAL LABORATORIES	d+d	SS	Ti, Pd POWDERS	THERMOCOUPLE	N		NO NEUTRONS OR EXCESS HEAT OBSERVED	CHECK OF FRASCATI
W.AYERS ELECTRON TRANSFER TECHNOLOGIES	d+d	ELECTROL	Pd CAST,DRAWN	CALORIMETRY	N		NULL RESULTS ON A VARIETY OF ELECTROCHEMICAL EXPERIMENTS: "NO CONTINUOUS EXCESS ENTHALPY"; NO Li IN Pd	CAREFUL CALORIMETRY AND PARTICLE DETECTION; COMPREHENSIVE EXPERIMENTS FOR UTAH EFFECT--NOT MUCH SPECIFIC IN POSTER SESSION
D.P.HUTCHINSON OAK RIDGE NATIONAL LABORATORY	d+d	ELECTROL	Pd EXTRUDED,C AST	CALORIMETRY			NO RESULTS GIVEN	SENSITIVE AT 1.5% OF APPLIED POWER
W.LINLOR	d+d	ELECTROL	Ni WIRE	TEMP.MEAS.			TWO RUNS SHOW 20% EXCESS POWER. TWO SUBSEQUENT SHOW NONE. 3 WITH NO LiCl SHOW NONE	

WARNING
data not verified by authors

1ST AUTHOR INSTITUTION	REACTION SOUGHT	CATEGORY	HOST MATERIALS	MEASUREMENT TECHNIQUE	HEAT OBSERVED?	EFFECT	RESULTS	COMMENTS
E.L.FULLER,JR OAK RIDGE NATIONAL LABORATORY	d+d	ELECTROL	Pd	UNKNOWN	N		NO EXCESS HEAT, NEUTRONS, GAMMA RAYS, OR HELIUM OBSERVED	ANALYZED BOTH ANODE AND CATHODE FOR He

WARNING
data not verified by authors

ELECTROCHEMICAL EXPERIMENTS--NEUTRON DETECTION

1ST AUTHOR & INSTITUTION	HOST MATER.	DETECTOR	NEUTRON RATE(/SEC)	BKGRND RATE	CLAIMED SIZE OF EFFECT	REACTION SOUGHT	(FUSIONS/PAIR/SEC)		RESULTS	COMMENTS
							MEAS. EFFECT	UPPER LIMIT		
K.L.WOLF TEXAS A&M UNIVERSITY	Pd AND Ti	NE213 LIQUID SCINTILLATOR	0.040-0.0 53	0.013/SEC	4XBACKGR ,8 SIGMA	d+d	8.E-22		NEUTRONS OBSERVED FROM 1 OF 25 SAMPLES, THE ONE BEING FROM A Pd-Ni ELECTROLYSIS CELL	5x10^12 TRITIUM ATOMS MEASURED, BUT ORIGINAL CONTENT NOT KNOWN; ALSO FRASCATI EXP., NO NEUTRONS OBSERVED
G.A.WURDEN MAX PLANCK INSTITUT FUR PLASMA PHYSIK	Pd, CAST	BF3 AND 6LiI	NULL		0	d+d			NO NEUTRONS, TRITIUM OR GAMMAS OBSERVED; NO EXCESS HEATING OBSERVED	LOADED Pd SAMPLE COOLED IN LN2; NO NEUTRONS OBSERVED
R.CROOKS MASSACHUSETTS INSTITUTE OF TECHNOLOGY	Pd ROD	MODERATED BF3	NULL	0.012 C/S	0	d+d			NO NEUTRONS, GAMMA RAYS, HEAT, TRITIUM, OR HELIUM-4 DETECTED	GAS BUBBLED THROUGH BUBBLER, H2O VS D2O AGREE TO 9%
D.R.MCCRACKEN CHALK RIVER NUCLEAR LABORATORIES	Pd, VARIOUS FORMS	3He AND 10BF3	NULL	8.E-3/SEC	0	d+d		1.2E-25	NO NEUTRONS OBSERVED, NO TRITIUM IN ELECTROLYTE OBSERVED	ALSO FRASCATI EXP., NO NEUTRONS OBSERVED
R.S.RAGHAVAN AT&T BELL LABORATORIES	Pd RODS, .125DIAx9CM	POLYETHYLENE & NaI	NULL	0.1/SEC	0; <.1n/s	d+d -> 3He+n		2.2E-24	NO NEUTRONS OBSERVED	

WARNING
data not verified by authors

1ST AUTHOR & INSTITUTION	HOST MATER.	DETECTOR	NEUTRON RATE(/SEC)	BKGRND RATE	CLAIMED SIZE OF EFFECT	REACTION SOUGHT	(FUSIONS/PAIR/SEC)		RESULTS	COMMENTS
							MEAS. EFFECT	UPPER LIMIT		
N.S.LEWIS CALIFORNIA INSTITUTE OF TECHNOLOGY	Pd, VAR FORMS	3He	NULL	75-85 C/HR	<100N/HR -CM3	d+d		8.E-25	NO NEUTRONS, GAMMA RAYS, TRITIUM, OR HEAT OBSERVED	SOME Pd 5 9'S PURITY
S.E.JONES BRIGHAM YOUNG UNIVERSITY	Ti,Pd	SCINT & Li6 GLASS COINCID	.00307/SEC	.00245/SEC	170 CTS;5.7 SIGMA	d+d	1.E-24		NEUTRONS OBSERVED, 0.04 NEUTRONS/SEC	REVIEW OF SEVERAL EXPERIMENTS ATTEMPTING TO UNDERSTAND CORRELATION OF FUSION YIELDS WITH PARAMETERS SUCH AS HYDROGEN/METAL RATIO, PRESSURE, TEMPERATURE VARIATIONS, HYDRIDE PHASE CHANGES, AND SURFACE CONDITIONS
A.BERTIN UNIVERSITA DI BOLOGNA	Ti	SCINT NE213	0.25	0.003/SEC	0.014 C/SEC	d+d->3He+n	1.E-24		OBSERVATION OF NEUTRONS RULES OUT COSMIC-RAY ORIGIN	EXPERIMENT CARRIED OUT UNDER GRAN SASSO MASSIF WHERE COSMIC-RAY INTENSITIES ARE VERY LOW; WILL LOOK FOR Pd GAMMA'S WITH ~0 BKGRND
M.GAI YALE UNIVERSITY	Pd, Ti, TiFeMnO POWD	LIQUID SCINT; NE213 PULSE	NULL	1.7+/-.4C/H	0	d+d, p+d		5.E-25	NO NEUTRONS OR GAMMA RAYS OBSERVED; NEUTRON 0.1+-0.2 COUNTS/HR	VARIOUS ELECTRODE PREPARATIONS; LOOK FOR ALL CHANNELS dd AND pd
H.HSUAN PRINCETON UNIVERSITY	Pd, Ti & OTHERS	BF3	NULL	0.001-0.008 /SEC	0	d+d, d+p			NO NEUTRONS OR GAMMA RAYS OBSERVED	APPARATUS COULD NOT DETECT NEUTRONS AS LOW AS JONES ET AL.; ALSO THEORY-REACTION RATES VS SEPARATION

WARNING
data not verified by authors

1ST AUTHOR & INSTITUTION	HOST MATER.	DETECTOR	NEUTRON RATE(/SEC)	BKGRND RATE	CLAIMED SIZE OF EFFECT	REACTION SOUGHT	(FUSIONS/PAIR/SEC) MEAS. EFFECT	(FUSIONS/PAIR/SEC) UPPER LIMIT	RESULTS	COMMENTS
D.S.GINLEY SANDIA NATIONAL LABORATORIES	Pd,Ti,Zr,V, CeCu5	3He & MODERATORS; Cd	NULL	3.E-3/SEC	0	d+d		1.E-26	NO NEUTRONS OR EXCESS HEAT OBSERVED	EXPERIMENTS DONE UNDERGROUND
S.GOTTESFIELD LOS ALAMOS NATIONAL LABORATORY	Pd	NE213 & 3He	NULL	0.06/SEC	0	D+D			NO NEUTRONS OR EXCESS HEAT OBSERVED	USED GAMMA-RAY DETECTORS TO LOOK FOR NEUTRON CAPTURE; CALORIMETRY PLANNED
D.GOZZI UNIVERSITA' DI ROMA	Pd	3He	BURSTS ONLY	3.5 C/H	BURST 36 N, 4 MIN	D+D			AFTER 150 HOURS, BURST OF NEUTRONS 150 TIMES BACKGROUND OBSERVED SIMULTANEOUSLY WITH A SHARP INCREASE OF ELECTRODE TEMPERATURE AFTER 150 HOURS; TRITIUM OBSERVED:(8.5 +/- 1.	
T.R.GUILINGER SANDIA NATIONAL LABORATORIES	Pd WIRE, EXTRUDED		NULL		0	D+D		1.E-22	NO NEUTRONS, PROTONS, OR TRITIUM DETECTED	HYDROGEN ABSORPTION EXPERIMENTS
J.C.HILL AMES LABORATORY	Pd	BF3	NULL		0	D+D			NO NEUTRONS OBSERVED FROM ELECTROLYSIS OR Ti-D PRESSURE CELL; NO GAMMA RAYS OBSERVED FROM Pd	GAMMA SENSITIVITY NOT GOOD

WARNING
data not verified by authors

1ST AUTHOR & INSTITUTION	HOST MATER.	DETECTOR	NEUTRON RATE(/SEC)	BKGRND RATE	CLAIMED SIZE OF EFFECT	REACTION SOUGHT	(FUSIONS/PAIR/SEC)		RESULTS	COMMENTS
							MEAS. EFFECT	UPPER LIMIT		
S.R.LITTLE AUSTIN COLD FUSION	Pd,Ti CAST	LiI	NULL	0.025/SEC	0	D+D		4.E-23	NO NEUTRONS, GAMMA RAYS, OR EXCESS HEAT OBSERVED	
C.A.MELENDRES ARGONNE NATIONAL LABORATORY	Pd	10B LOADED LIQUID SCINT	NULL	0.6/SEC	0	D+D			NO NEUTRONS, GAMMA RAYS, OR TRITIUM OBSERVED	
J.D.PORTER UNIVERSITY OF CALIFORNIA AT BERKELEY	Pd, WIRE, DISKS, FOIL	MOD.+GE, LIQ. SCINT., 3HE	NULL		0	D+D		1.E-22	NO NEUTRONS OR CHARGED PARTICLES OBSERVED	THREE EXPERIMENTS; IMPRESSIVE LIMIT ON PROTON EMISSION
C.D.SCOTT OAK RIDGE NATIONAL LABORATORY	Pd, CAST	NE213 SCINT	NULL?		MAYBE 4 SIGMA	D+D			NO HEAT OR GAMMA RAYS OBSERVED; SMALL INCREASE IN TRITIUM, PROBABLY EVAPORATIONS; NEUTRON BKG RATE FLUCTUATES, MAY BE SIGNIFICANT, 4 SIGMA AT ONE POINT	
H.W.RANDOLPH WESTINGHOUSE SAVANNAH RIVER COMPANY	Pd		NULL		0	D+D			NO HEAT, NEUTRONS, GAMMA RAYS OBSERVED	CAREFUL CALORIMETRY W/NULL RESULT. ELECTRODE LOADS IN HOUR; MEASURE BY REVERSING CURRENT; PRELIMINARY; SHORT RUNNING TIME. WILL CONTINUE; TRITIUM & HELIUM MEASURED?

WARNING
data not verified by authors

1ST AUTHOR & INSTITUTION	HOST MATER.	DETECTOR	NEUTRON RATE(/SEC)	BKGRND RATE	CLAIMED SIZE OF EFFECT	REACTION SOUGHT	(FUSIONS/PAIR/SEC) MEAS. EFFECT	UPPER LIMIT	RESULTS	COMMENTS
P.TOMAS RUDER BOSKOVIC INSTITUTE, ZAGREB, YUGOSLAVIA	Pd SHEETS, CAST	6Li GLASS	NULL	<.01/S	0	D+D->n+3He		2.7E-24	NO NEUTRONS OBSERVED, LESS THAN 0.01 N/S/GM	EXPERIMENTS IN UNDERGROUND LABORATORY
G.R.LONGHURST IDAHO NATIONAL ENGINEERING LABORATORY	Pd FOIL & RODS	BC501 LIQ SCINT	NULL	100/SEC	0	d+d			NO NEUTRONS, GAMMA RAYS, TRITIUM OR EXCESS HEAT OBSERVED; TRITIUM < 1.E-6 MICRO CURIE/ML	EVALUATED NON-NUCLEAR HEAT PRODUCTION WITH CONCLUSION THAT UTAH EFFECTS COULD BE EXPLAINED BY NON-NUCLEAR PHENOMENA
R.E.ANDERSON LOS ALAMOS NATIONAL LABORATORY	Pd	POLY MODER 3He & OTHERS	NULL		0	d+d			NO NEUTRONS OR GAMMA RAYS OBSERVED	LARGE RANGE EXPERIMENTS IN WELL COUNTERS SHOW NOTHING, EITHER FRASCATI OR PONS TYPE; AUTHORS CAUTIOUS ABOUT CLAIMS; 3 EXPERIMENTS
F.BESENBACHER UNIVERSITY OF AARHUS, DENMARK	Pd, Ti	NE213 W PSD	NULL	0.01/SEC	0	dd->3He+n		1.E-23	NO NEUTRONS ABOVE BACKGROUND	2 EXPERIMENTS
C.ELLEGAARD UNIVERSITY OF COPENHAGEN	Pd, Ti	3 l LIQ SCINT NE213	NULL		0	d+d->3He+n			NULL RESULT AT OR BELOW JONES LEVEL, NEUTRON YIELDS	ALSO FRASCATI TYPE MEASUREMENT; Ti SHAVINGS IN D2O; NO BURSTS OBSERVED

WARNING
data not verified by authors

1ST AUTHOR & INSTITUTION	HOST MATER.	DETECTOR	NEUTRON RATE(/SEC)	BKGRND RATE	CLAIMED SIZE OF EFFECT	REACTION SOUGHT	(FUSIONS/PAIR/SEC) MEAS. EFFECT	UPPER LIMIT	RESULTS	COMMENTS
D.P.HUTCHINSON OAK RIDGE NATIONAL LABORATORY	Pd, PRELOADED	NE213 SCINT.	NULL	200/HR	0	d+d->3He+n		2.1E-23	NO NEUTRONS OBSERVED	NO COUNTS ABOVE BACKGROUND; MINIMUM DETECTABLE LEVEL ~200 CTS/HR AT 3 SIGMA
K.G.LYNN BROOKHAVEN NATIONAL LABORATORY	Pd, Ti	LIQ SCIN/BF3	NULL		0	dd, pd		1.E-25	NO NEUTRONS, PROTONS, BETA PARTICLES, XRAYS OR GAMMA RAYS OBSERVED; LESS THAN 10^-22 FUSIONS/PAIR/SEC FOR p+d	VERY THOROUGH SEARCH FOR ANYTHING INDICATING FUSION; NEGATIVE
S.NAKABAYASHI CHEMICAL DYNAMICS LABORATORY, RIKEN	Pd, PRELOADED	NE213 W/PSD	NULL	.003/SEC	0	d+d		9.E-25	NO NEUTRONS OBSERVED; <9E-25 (VOLUME); 1.8E-22 (SURFACE)	ELECTRODES TO BE ANALYZED FOR d, 3He, 4He
R.A.HENDERSON LAWRENCE BERKELEY LABORATORY	Pd, Ti	LIQ SCINT, NE213	NULL	0.1/SEC	0	d+d, d+p		4.E-24	NO NEUTRONS OR GAMMA RAYS OBSERVED; REACTIONS/SEC/PARTS LIMITS ARE 2.1x10^-24 FOR dd->3He n, 2.7E-24 FUSIONS/d/SEC FOR dd->4He+GAMMA, AND 1.8E-23 FOR pd->3He+	VERY STRONG NEGATIVE RESULT
T.L.LIN NATIONAL TSING-HUA UNIVERSITY	Pd ROD	3He AND BF3	NULL?	0.01/SEC		dd->3He n			NEUTRON COUNTS "ONLY SLIGHTLY ABOVE BACKGROUND"; AT ONE TIME, DETECTED NEUTRONS APPRECIABLY HIGHER THAN BACKGROUND	

WARNING
data not verified by authors

1ST AUTHOR & INSTITUTION	HOST MATER.	DETECTOR	NEUTRON RATE(/SEC)	BKGRND RATE	CLAIMED SIZE OF EFFECT	REACTION SOUGHT	(FUSIONS/PAIR/SEC) MEAS. EFFECT	UPPER LIMIT	RESULTS	COMMENTS
J.F.WACKER BATTELLE PACIFIC NORTHWEST LABORATORIES	Pd	WELL TYPE Ge PLUS Cd	NULL		0	d+d		6.E-23	NO NEUTRONS, PARTICLES, OR TRITIUM OBSERVED	
S.A.WENDER LOS ALAMOS NATIONAL LABORATORY	Pd FOILS, PRECHARGED	NE213 W/PSD	NULL		0	p+d			NO NEUTRON COUNTS ABOVE BACKGROUND	RESULTS AT INCREASED SENSITIVITY TO BE REPORTED
Y.DUFOUR COLLEGE DE FRANCE, PARIS	Pd,Ti	NE320 SCINT	NULL	SEE COMMENTS	0	d+d->3He+n			NO NEUTRONS OBSERVED, LESS THAN 1.2/HR; VERY SENSITIVE EXP.	USED 6Li-LOADED LIQUID SCINTILLATOR AND MEASURED SLOWING-DOWN PULSE SEPARATELY FROM CAPTURE PULSE AND DO PULSE HEIGHT AND PULSE SHAPE ON BOTH; BKG. RATE 7/HR BUGEY, 2 IN 5 DAYS FREJUS
E.L.FULLER,JR OAK RIDGE NATIONAL LABORATORY	Pd	MODERATED BF3	NULL	1/SEC	0	d+d			NO EXCESS HEAT, NEUTRONS, GAMMA RAYS, OR HELIUM OBSERVED	ANALYZED BOTH ANODE AND CATHODE FOR He

WARNING
data not verified by authors

ELECTROCHEMICAL EXPERIMENTS--GAMMA RAY DETECTION

1ST AUTHOR & INSTITUTION	HOST MATER.	DETECTOR	GAMMA RATE(/SEC)	BKGRND RATE	CLAIMED SIZE OF EFFECT	REACTION SOUGHT	(FUSIONS/PAIR/SEC)		RESULTS	COMMENTS
							MEAS. EFFECT	UPPER LIMIT		
K.L.WOLF TEXAS A&M UNIVERSITY	Pd AND Ti		NULL		0	d+d			NEUTRONS OBSERVED FROM 1 OF 25 SAMPLES, THE ONE BEING FROM A Pd-Ni ELECTROLYSIS CELL	5x10^12 TRITIUM ATOMS MEASURED, BUT ORIGINAL CONTENT NOT KNOWN; ALSO FRASCATI EXP., NO NEUTRONS OBSERVED
G.A.WURDEN MAX PLANCK INSTITUT FUR PLASMA PHYSIK	Pd, CAST	GeLi AND NaI	NULL		0	d+d			NO NEUTRONS, TRITIUM OR GAMMAS OBSERVED; NO EXCESS HEATING OBSERVED	LOADED Pd SAMPLE COOLED IN LN2; NO NEUTRONS OBSERVED
R.CROOKS MASSACHUSETTS INSTITUTE OF TECHNOLOGY	Pd ROD	NaI 3"	NULL		0	d+d			NO NEUTRONS, GAMMA RAYS, HEAT, TRITIUM, OR HELIUM-4 DETECTED	GAS BUBBLED THROUGH BUBBLER, H2O VS D2O AGREE TO 9%
N.S.LEWIS CALIFORNIA INSTITUTE OF TECHNOLOGY	Pd, VAR FORMS	Ge & NaI	NULL		0	d+d			NO NEUTRONS, GAMMA RAYS, TRITIUM, OR HEAT OBSERVED	SOME Pd 5 9'S PURITY
M.GAI YALE UNIVERSITY	Pd, Ti, TiFeMnO POWD	NaI	NULL	1 OR 5C/H/CH	0	p+d		1.E-22	NO NEUTRONS OR GAMMA RAYS OBSERVED; NEUTRON 0.1+-0.2 COUNTS/HR	VARIOUS ELECTRODE PREPARATIONS; LOOK FOR ALL CHANNELS dd AND pd

WARNING
data not verified by authors

1ST AUTHOR & INSTITUTION	HOST MATER.	DETECTOR	GAMMA RATE(/SEC)	BKGRND RATE	CLAIMED SIZE OF EFFECT	REACTION SOUGHT	(FUSIONS/PAIR/SEC)		RESULTS	COMMENTS
							MEAS. EFFECT	UPPER LIMIT		
H.HSUAN PRINCETON UNIVERSITY	Pd, Ti & OTHERS	NaI	NULL	0.001-0.00 6/SEC	0	d+d, d+p			NO NEUTRONS OR GAMMA RAYS OBSERVED	APPARATUS COULD NOT DETECT NEUTRONS AS LOW AS JONES ET AL.; ALSO THEORY-REACTION RATES VS SEPARATION
J.C.HILL AMES LABORATORY	Pd	Ge(Li)	NULL		0	D+D			NO NEUTRONS OBSERVED FROM ELECTROLYSIS OR Ti-D PRESSURE CELL; NO GAMMA RAYS OBSERVED FROM Pd	GAMMA SENSITIVITY NOT GOOD
S.R.LITTLE AUSTIN COLD FUSION	Pd,Ti CAST	NaI	NULL	.078/SEC	0	D+D			NO NEUTRONS, GAMMA RAYS, OR EXCESS HEAT OBSERVED	
C.A.MELENDRES ARGONNE NATIONAL LABORATORY	Pd	NaI	NULL	1.6/SEC	0	D+D			NO NEUTRONS, GAMMA RAYS, OR TRITIUM OBSERVED	
C.D.SCOTT OAK RIDGE NATIONAL LABORATORY	Pd, CAST	NaI	NULL		0	D+D			NO HEAT OR GAMMA RAYS OBSERVED; SMALL INCREASE IN TRITIUM, PROBABLY EVAPORATIONS; NEUTRON BKG RATE FLUCTUATES, MAY BE SIGNIFICANT, 4 SIGMA AT ONE POINT	

WARNING
data not verified by authors

1ST AUTHOR & INSTITUTION	HOST MATER.	DETECTOR	GAMMA RATE(/SEC)	BKGRND RATE	CLAIMED SIZE OF EFFECT	REACTION SOUGHT	(FUSIONS/PAIR/SEC)		RESULTS	COMMENTS
							MEAS. EFFECT	UPPER LIMIT		
H.W.RANDOLPH WESTINGHOUSE SAVANNAH RIVER COMPANY	Pd	NaI, Ge	NULL		0	D+D			NO HEAT, NEUTRONS, GAMMA RAYS OBSERVED	CAREFUL CALORIMETRY W/NULL RESULT. ELECTRODE LOADS IN HOUR; MEASURE BY REVERSING CURRENT; PRELIMINARY; SHORT RUNNING TIME. WILL CONTINUE; TRITIUM & HELIUM MEASURED?
G.R.LONGHURST IDAHO NATIONAL ENGINEERING LABORATORY	Pd FOIL & RODS		NULL		0	d+d			NO NEUTRONS, GAMMA RAYS, TRITIUM OR EXCESS HEAT OBSERVED; TRITIUM < 1.E-6 MICRO CURIE/ML	EVALUATED NON-NUCLEAR HEAT PRODUCTION WITH CONCLUSION THAT UTAH EFFECTS COULD BE EXPLAINED BY NON-NUCLEAR PHENOMENA
R.E.ANDERSON LOS ALAMOS NATIONAL LABORATORY	Pd		NULL		0	d+d			NO NEUTRONS OR GAMMA RAYS OBSERVED	LARGE RANGE EXPERIMENTS IN WELL COUNTERS SHOW NOTHING, EITHER FRASCATI OR PONS TYPE; AUTHORS CAUTIOUS ABOUT CLAIMS; 3 EXPERIMENTS
K.G.LYNN BROOKHAVEN NATIONAL LABORATORY	Pd, Ti	12.5 CM NaI	NULL		0	pd		1.E-22	NO NEUTRONS, PROTONS, BETA PARTICLES, XRAYS OR GAMMA RAYS OBSERVED; LESS THAN 10^-22 FUSIONS/PAIR/SEC FOR p+d	VERY THOROUGH SEARCH FOR ANYTHING INDICATING FUSION; NEGATIVE
R.A.HENDERSON LAWRENCE BERKELEY LABORATORY	Pd, Ti	NaI	NULL	1/SEC	0	d+p		4.E-23	NO NEUTRONS OR GAMMA RAYS OBSERVED; REACTIONS/SEC/PARTS LIMITS ARE 2.1x10^-24 FOR dd->3He n, 2.7E-24 FUSIONS/d/SEC FOR dd->4He+GAMMA, AND 1.8E-23 FOR pd->3He+	VERY STRONG NEGATIVE RESULT

WARNING
data not verified by authors

1ST AUTHOR & INSTITUTION	HOST MATER.	DETECTOR	GAMMA RATE(/SEC)	BKGRND RATE	CLAIMED SIZE OF EFFECT	REACTION SOUGHT	(FUSIONS/PAIR/SEC)		RESULTS	COMMENTS
							MEAS. EFFECT	UPPER LIMIT		
S.A.WENDER LOS ALAMOS NATIONAL LABORATORY	Pd FOILS, PRECHARGED	3X3 BGO W/ACTIVE SHIELD	NULL	4.3E-3/SEC	0	p+d		1.9E-24	NO NEUTRON COUNTS ABOVE BACKGROUND	RESULTS AT INCREASED SENSITIVITY TO BE REPORTED
E.L.FULLER,JR OAK RIDGE NATIONAL LABORATORY	Pd		NULL		0	d+d			NO EXCESS HEAT, NEUTRONS, GAMMA RAYS, OR HELIUM OBSERVED	ANALYZED BOTH ANODE AND CATHODE FOR He

WARNING
data not verified by authors

EXPERIMENTS--CHARGED PARTICLE DETECTION

1ST AUTHOR & INSTITUTION	HOST MATER.	HOST PREPARATION	CHARGED PARTICLE RATE	CLAIMED SIZE OF EFFECT	REACTION SOUGHT	(FUSIONS/PAIR/SEC) MEAS. EFFECT	(FUSIONS/PAIR/SEC) UPPER LIMIT	RESULTS	COMMENTS
J.F.ZIEGLER THOMAS J. WATSON RESEARCH CENTER	Pd FOILS	ELECTROCHEMICAL	NULL	0	dd,pd		1.5E-25	NO ENERGETIC CHARGED PARTICLES OBSERVED	SIX EXPERIMENTS LOOKING FOR CHARGED PARTICLES; HYDROGENATION FROM X-RAY DIFFRACTION
S.M.MYERS SANDIA NATIONAL LABORATORIES	Pd, Zr	ION IMPL.AT 10KEV,40K	NULL	0	D-D		1.E-21	NO CHARGED PARTICLES OBSERVED	ION IMPLANTED AT LOW T
S.W.BARWICK UNIVERSITY OF CALIFORNIA AT BERKELEY	Pd, Ti	PRESSURE LOADED	NULL	0	D+D			NO 3HE IONS OBSERVED	LIMIT FAR LOWER THAN RATES CLAIMED IN FRASCATI AND GENOA EXPERIMENTS
B.U.R.SUNDQVIST UPPSALA UNIVERSITY	Pd	ELECTROCHEMICAL	NULL	0	D+D->p+t		2.E-24	NO PROTONS OBSERVED	
G.CHAMBERS NAVAL RESEARCH LABORATORY, WASHINGTON	Pd FILM, SPUTTERED	ION IMPLANTATION	NULL	0	D+D			NO FIRM EVIDENCE FOR ENERGETIC PARTICLES; FOR TARGET AT HIGH TEMPERATURE, SEVERAL COUNTS SEEN BUT ARE IN QUESTION	ION IMPLANTED DEUTERONS INTO Pd FOIL, LOOKED FOR ENERGETIC PARTICLES

WARNING
data not verified by authors

1ST AUTHOR & INSTITUTION	HOST MATER.	HOST PREPARATION	CHARGED PARTICLE RATE	CLAIMED SIZE OF EFFECT	REACTION SOUGHT	(FUSIONS/PAIR/SEC)		RESULTS	COMMENTS
						MEAS. EFFECT	UPPER LIMIT		
T.R.GUILINGER SANDIA NATIONAL LABORATORIES	Pd WIRE, EXTRUDED	ELECTROCHEMICAL	NULL	0	D+D			NO NEUTRONS, PROTONS, OR TRITIUM DETECTED	HYDROGEN ABSORPTION EXPERIMENTS
M.A.PRELAS UNIVERSITY OF MISSOURI-COLUMBIA	Pd, Ti, Ni, Ta	ION IMPLANTATION	NULL	0	D+D			COUNTS ABOVE BACKGROUND?	ATTEMPTS TO OBSERVE CF IN PLASMAS; CLAIM COUNTS ABOVE BACKGROUND; HEALTH PHYSICS MONITORS?
J.D.PORTER UNIVERSITY OF CALIFORNIA AT BERKELEY	Pd, WIRE, DISKS, FOIL	ELECTROCHEMICAL	NULL	0	D+D		7.E-25	NO NEUTRONS OR CHARGED PARTICLES OBSERVED	THREE EXPERIMENTS; IMPRESSIVE LIMIT ON PROTON EMISSION
K.G.LYNN BROOKHAVEN NATIONAL LABORATORY	Pd, Ti	ELECTROCHEMICAL	NULL	0	dd			NO NEUTRONS, PROTONS, BETA PARTICLES, XRAYS OR GAMMA RAYS OBSERVED; LESS THAN 10^-22 FUSIONS/PAIR/SEC FOR p+d	VERY THOROUGH SEARCH FOR ANYTHING INDICATING FUSION; NEGATIVE
J.F.WACKER BATTELLE PACIFIC NORTHWEST LABORATORIES	Pd	ELECTROCHEMICAL	NULL	0	d+d			NO NEUTRONS, PARTICLES, OR TRITIUM OBSERVED	

WARNING
data not verified by authors

1ST AUTHOR & INSTITUTION	HOST MATER.	HOST PREPARATION	CHARGED PARTICLE RATE	CLAIMED SIZE OF EFFECT	REACTION SOUGHT	(FUSIONS/PAIR/SEC) MEAS. EFFECT	UPPER LIMIT	RESULTS	COMMENTS
K.E.REHM ARGONNE NATIONAL LABORATORY	Pd FOIL	ELECTROCHEMICAL	NULL	0	d+d->p+3H			NO PROTONS OBSERVED; LESS THAN 5.5E-4/SEC	
J.A.KNAPP SANDIA NATIONAL LABORATORIES	Pd, Ti FOILS	ELECTROCHEMICAL	NULL	0	d+d		2.E-24	NO PROTONS OBSERVED; LESS THAN 8.E-4/SEC	USED NUCLEAR MICROPROBE TO MEASURE DEUTERIUM PROFILE IN SITU
F.E.CECIL	Pd FOIL	ION IMPLANTATION	30 C/S	4 SD	d+d	2.E-21		PARTICLE GROUPS OF 3 AND 5 MeV OBSERVED; PRODUCTION RATE OF 100 PARTICLES/CM3/SEC	CURRENT RUN THROUGH FOIL (FOLLOWING ION BOMBARDMENT) TO GET EFFECT; CURRENT DENSITIES UP TO 20 AMPS/CM2

WARNING
data not verified by authors

PRESSURE-LOADED SAMPLE EXPERIMENTS

1ST AUTHOR INSTITUTION	HOST MATER.	CHANGE IN TEMP (K)	TEMPERATURE (K)	PRESSURE (PSI)	REACTION SOUGHT	RESULTS	COMMENTS
D.R.MCCRACKEN CHALK RIVER NUCLEAR LABORATORIES	Ti	77-300	289-323		d+d	NO NEUTRONS OBSERVED, NO TRITIUM IN ELECTROLYTE OBSERVED	ALSO FRASCATI EXP., NO NEUTRONS OBSERVED
J.G.BLENCOE OAK RIDGE NATIONAL LABORATORY	Pd AND Ti	195-300	300	52000	d+d	NO NEUTRON OR HEAT PRODUCTION MEASURED	PURPOSE: INVESTIGATE WHETHER ELECTROLYSIS NECESSARY; SEE HEAT, PROBABLY FROM DEUTERIDE FORMATION OR GAS CONDENSATION
H.O.MENLOVE LOS ALAMOS NATIONAL LABORATORY	Ti METAL CHIPS/SPONGE	77-200	300	300-750	d+d->3He+n	RANDOM NEUTRONS AND BURSTS OF SEVERAL HUNDRED NEUTRONS OBSERVED DURING WARMUP; TIME SPREAD LESS THAN 200 MICROSEC FOR BURSTS	DETECTED BURSTS OF NEUTRONS; IN SOME CASES, Ti COATED WITH A SURFACE LAYER OF Pd; SOME BURSTS AT ROOM TEMPERATURE
A.DENINNO ENEA	Ti SHAVINGS OR SPONGE			<= 750	d+d->3He+n	BURSTS OF NEUTRONS MANY TIMES BACKGROUND OBSERVED	3 MASSES 10 ATTEMPTS; BURSTS OF NEUTRONS DETECTED; DETECTOR DEAD TIME 2-3 MICROSEC, MODERATOR DISPERSAL 60 MICROSEC
M.GAI YALE UNIVERSITY	Ti				d+d	NO NEUTRONS OR GAMMA RAYS OBSERVED; NEUTRON 0.1+-0.2 COUNTS/HR	VARIOUS ELECTRODE PREPARATIONS; LOOK FOR ALL CHANNELS dd AND pd

WARNING
data not verified by authors

1ST AUTHOR INSTITUTION	HOST MATER.	CHANGE IN TEMP (K)	TEMPERATURE (K)	PRESSURE (PSI)	REACTION SOUGHT	RESULTS	COMMENTS
H.HSUAN PRINCETON UNIVERSITY	Ti & OTHERS				d+d	NO NEUTRONS OR GAMMA RAYS OBSERVED	APPARATUS COULD NOT DETECT NEUTRONS AS LOW AS JONES ET AL.; ALSO THEORY-REACTION RATES VS SEPARATION
S.W.BARWICK UNIVERSITY OF CALIFORNIA AT BERKELEY	Pd, Ti	77-300	300	0-225	D+D	NO 3HE IONS OBSERVED	LIMIT FAR LOWER THAN RATES CLAIMED IN FRASCATI AND GENOA EXPERIMENTS
J.C.HILL AMES LABORATORY	Pd, Ti	77-1100			D+D	NO NEUTRONS OBSERVED FROM ELECTROLYSIS OR Ti-D PRESSURE CELL; NO GAMMA RAYS OBSERVED FROM Pd	GAMMA SENSITIVITY NOT GOOD
P.A.SEEGER LOS ALAMOS NATIONAL LABORATORY	Pd			110	d+d	NO NEUTRONS CORRELATED WITH HEATING OBSERVED; MODEST HEATING ATTRIBUTED TO ELECTRICALLY DRIVEN CHEMICAL REACTION OF UNKNOWN ORIGIN	INJECTED ELECTRONS INTO DEUTERIUM--LOADED Pd, SO THAT THE ELECTRON CONCENTRATION IN THE METAL WOULD BE THE NON-EQUILIBRIUM STATE FOR A SHORT TIME
X.Y.WANG PEKING UNIVERSITY	Ti		94	450	d+d	NO RESULTS	NO RESULTS PRESENTED FROM EITHER ELECTROLYSIS OR SOLID STATE

WARNING
data not verified by authors

1ST AUTHOR INSTITUTION	HOST MATER.	CHANGE IN TEMP (K)	TEMPERATURE (K)	PRESSURE (PSI)	REACTION SOUGHT	RESULTS	COMMENTS
N.AGRAIT UNIVERSIDAT AUTONOMA DE MADRID	Ti	77-300	300	2250	d+d->3He+n	NO NEUTRONS OBSERVED	TRANSIENT TEMPERATURE EXPERIMENTS
R.E.ANDERSON LOS ALAMOS NATIONAL LABORATORY	Ti				d+d	NO NEUTRONS OR GAMMA RAYS OBSERVED	LARGE RANGE EXPERIMENTS IN WELL COUNTERS SHOW NOTHING, EITHER FRASCATI OR PONS TYPE; AUTHORS CAUTIOUS ABOUT CLAIMS; 3 EXPERIMENTS
C.ELLEGAARD UNIVERSITY OF COPENHAGEN	Ti				d+d->3He+n	NULL RESULT AT OR BELOW JONES LEVEL, NEUTRON YIELDS	ALSO FRASCATI TYPE MEASUREMENT; Ti SHAVINGS IN D2O; NO BURSTS OBSERVED
M.M.FOWLER LOS ALAMOS NATIONAL LABORATORY	Ti				d+d	NO NEUTRONS OR Pd XRAYS FROM ELECTROCHEMICAL CELLS, MAYBE SOME FROM "FRASCATI" TYPE	VARIETY OF EXPERIMENTS OF JONES, FRASCATI TYPE
E.GARCIA LOS ALAMOS NATIONAL LABORATORY	Ti	77-300	300	90-1500	d+d->3He+n	NEUTRON BURSTS FROM SOME SAMPLES	INVESTIGATING FRACTURE OR STRAIN MECHANISM. CHARGED PARTICLES ACCOMPANYING FRACTURE OBSERVED

WARNING
data not verified by authors

1ST AUTHOR INSTITUTION	HOST MATER.	CHANGE IN TEMP (K)	TEMPERATURE (K)	PRESSURE (PSI)	REACTION SOUGHT	RESULTS	COMMENTS
J.E.SCHIRBER SANDIA NATIONAL LABORATORIES	Ti, Pd POWDERS	77-300	300	10,500-36,000	d+d	NO NEUTRONS OR EXCESS HEAT OBSERVED	CHECK OF FRASCATI
A.G.GU MISSISSIPPI STATE UNIVERSITY	Pd				d+d->3He+n	RESULTS NOT GIVEN?	LOOKED FOR NEUTRONS FROM DEUTERIUM GAS OR PLASMA IN PRESENCE OF PALLADIUM

WARNING
data not verified by authors

HOST PHYSICAL PROPERTIES--EXPERIMENTAL STUDIES

1ST AUTHOR & INSTITUTION	COMMENTS	RESULTS
G.S.COLLINS WASHINGTON STATE UNIVERSITY	INVESTIGATING H INTERACTIONS IN METALS BY PERTURBED ANGULAR CORRELATIONS	
F.BESENBACHER UNIVERSITY OF AARHUS	INTERACTION OF D IN PD INVESTIGATED BY ION-BEAM-ANALYSIS TECHNIQUES	
T.R.GUILINGER SANDIA NATIONAL LABORATORIES	HYDROGEN ABSORPTION EXPERIMENTS	NO NEUTRONS, PROTONS, OR TRITIUM DETECTED
G.L.POWELL OAK RIDGE Y-12 PLANT	Pd CASTING; PROPERTIES OF CAST Pd-VOIDS, HYDROGEN ABSORPTION	
F.LYTLE THE BOEING COMPANY	USED EXAFS TO EXAMINE HYDROGEN AND DEUTERIUM LOADING OF A Pd LATTICE IN SITU WITH AN XRAY TRANSPARENT CELL	BAND DISTANCE AND LATTICE DISORDER MEASURED
J.O'M.BOCKRIS TEXAS A&M UNIVERSITY	DISCUSSES THE ROLE OF STRESS NEAR DISLOCATIONS AS SOURCES OF CONCENTRATIONS OF D ATOMS UNDER CONDITIONS OF HIGH PRESSURE	
B.M.OLIVER ROCKWELL INTERNATIONAL	CAREFUL MASS SPECTROSCOPY OF ELECTRODES FROM SEVERAL LABS; THIS COULD BE IMPORTANT, DEPENDING ON WHAT ELSE IS CLAIMED FOR THESE ELECTRODES. SOME FROM LLNL, SNLL, MIT, A&M, ORNL, NAVAL OCEAN SYSTEM CENTER, ELECTRON TRANSFER TECHNOLOGIES	NO 3He OR 4He DETECTED IN VARIOUS Pd SAMPLES; EQUIVALENT TO LESS THAN 0.1 MICROWATTS PER GRAM Pd IN ELECTRODES TESTED
M.YANOKURA LINAC LABORATORY, RIKEN	ATTEMPT TO ANALYZE DEUTERON AND PROTON CONTENT OF ELECTRODES BY ARGON BEAM BOMBARDMENT	FEW DEUTERONS OBSERVED

WARNING
data not verified by authors

1ST AUTHOR & INSTITUTION	COMMENTS	RESULTS
J.A.KNAPP SANDIA NATIONAL LABORATORIES	USED NUCLEAR MICROPROBE TO MEASURE DEUTERIUM PROFILE IN SITU	NO PROTONS OBSERVED; LESS THAN 8.E-4/SEC

WARNING
data not verified by authors

EXPERIMENTS SEARCHING FOR MUON-INDUCED COLD FUSION

1ST AUTHOR INSTITUTION	REACTION SOUGHT	HOST MATERIALS	HOST PREPARATION	RESULTS	COMMENTS
M.CHEN MASSACHUSETTS INSTITUTE OF TECHNOLOGY	d+d	Pd,Ti	ELECTROCHEM OR PRESS	NO HEAT, NEUTRONS, GAMMA RAYS, OR HELIUM OBSERVED	SAMPLES EXPOSED TO 80 MeV/c MUON BEAM; CONTROL TARGETS AIR, D2O, Pb, D2, Pd
K.NAGAMINE UNIVERSITY OF TOKYO	d+d	Pd	D LOADING & ELECTROCH	NO DECAY ELECTRONS, NEUTRONS, OR XRAYS OBSERVED	USE ACCELERATOR MUONS; SUGGESTION FOR ENHANCEMENT; RECOIL FOR MUON XRAYS MAKES VACANCY
J.H.BREWER UNIVERSITY OF BRITISH COLUMBIA	d+d->3He+n	Pd	ELECTROCHEMICAL	NO MUON-INDUCED COLD FUSION NEUTRONS OBSERVED	LOOKING FOR MUON INDUCED d+d

WARNING
data not verified by authors

ION-IMPLANTED OR PLASMA-CHARGED SAMPLE EXPERIMENTS

1ST AUTHOR INSTITUTION	REACTION SOUGHT	HOST MATERIALS	RESULTS	COMMENTS
S.M.MYERS SANDIA NATIONAL LABORATORIES	D-D	Pd, Zr	NO CHARGED PARTICLES OBSERVED	ION IMPLANTED AT LOW T
G.CHAMBERS NAVAL RESEARCH LABORATORY, WASHINGTON	D+D	Pd FILM, SPUTTERED	NO FIRM EVIDENCE FOR ENERGETIC PARTICLES; FOR TARGET AT HIGH TEMPERATURE, SEVERAL COUNTS SEEN BUT ARE IN QUESTION	ION IMPLANTED DEUTERONS INTO Pd FOIL, LOOKED FOR ENERGETIC PARTICLES
M.A.PRELAS UNIVERSITY OF MISSOURI-COLUMBIA	D+D	Pd, Ti, Ni, Ta	COUNTS ABOVE BACKGROUND?	ATTEMPTS TO OBSERVE CF IN PLASMAS; CLAIM COUNTS ABOVE BACKGROUND; HEALTH PHYSICS MONITORS?
E.K.STORMS LOS ALAMOS NATIONAL LABORATORY	d+d;d+p;d+t	Pd	NO RESULTS	
F.BESENBACHER UNIVERSITY OF AARHUS, DENMARK	dd->3He+n	Pd, Ti	NO NEUTRONS ABOVE BACKGROUND	2 EXPERIMENTS

WARNING
data not verified by authors

1ST AUTHOR INSTITUTION	REACTION SOUGHT	HOST MATERIALS	RESULTS	COMMENTS
T.G.DIGNAN	d+d	Pd FILMS	LIMIT OF LESS THAN 35 NEUTRONS SEC-1 FROM 10^21 DEUTERONS. LESS THAN 10 24 MeV GAMMAS PER HOUR	LOOKED FOR GAMMAS FROM NEUTRONS CAPTURED IN PARAFFIN MODERATOR; NO INFORMATION ABOUT BACKGROUND; NEUTRON PRODUCTION LIMITS WELL ABOVE RATE OBSERVED IN ELECTROLYSIS EXPERIMENTS
A.G.GU MISSISSIPPI STATE UNIVERSITY	d+d->3He+n	Pd	RESULTS NOT GIVEN?	LOOKED FOR NEUTRONS FROM DEUTERIUM GAS OR PLASMA IN PRESENCE OF PALLADIUM
F.E.CECIL	d+d	Pd FOIL	PARTICLE GROUPS OF 3 AND 5 MeV OBSERVED; PRODUCTION RATE OF 100 PARTICLES/CM3/SEC	CURRENT RUN THROUGH FOIL (FOLLOWING ION BOMBARDMENT) TO GET EFFECT; CURRENT DENSITIES UP TO 20 AMPS/CM2

WARNING
data not verified by authors

THEORY REPORTS

1ST AUTHOR & INSTITUTION	METHOD	SUBJECT OF INVESTIGATION	RESULTS	COMMENTS
SUBCATEGORY: CHEM & SS				
P.M.RICHARDS SANDIA NATIONAL LABORATORIES	MOLECULAR DYNAMICS	d-d SEPARATION IN Pd	SOME SEPARATIONS < 1.5A, NO < 0.7A	OCTAHEDRAL 2.83A, TETRAHEDRAL 1.73A; NEED SCREENING LENGTH 1/4 AZERO
A.E.PONTAU SANDIA NATIONAL LABORATORIES		HEAT PRODUCTION	P&F ENERGY DEFICIT FROM EVAPORATIVE ENERGY LOSS	QUESTION HEAT MEASUREMENTS OF P&F
J.O'M.BOCKRIS TEXAS A&M UNIVERSITY	DISCUSSION OF CHEMISTRY & METALLURGY			WANT TO EXPLAIN 10W/CM3 1) 100% RECOMB AND COMPARE TO (E-1.54)I GET 18.6 WATTS. EXPT SAYS 98% COMBINED 2) FREYSA PUMP RECOMB ABOVE WATER LINE < .2 W/CM3 NOT OBSERVED; 3) RECOMB IN BUBBLES < .3W/CM3 4)ALPHA
J.BIGELEISEN STATE UNIVERSITY OF NEW YORK, STONY BROOK		TRITIUM CONTENT OF HEAVY WATER	ENRICHMENT INCREASES AS FRACTION OF WATER ELECTROLYZED INCREASES	
F.J.MAYER FJM ASSOCIATES		PARTICLE ACCELERATION IN CRACKS	WATTS OF ELECTRICAL POWER MAY BE RELEASED; FAST DEUTERONS MAY INITIATE D+D	
A.F.ABUTAHA		RELEASE OF STORED STRAIN ENERGY	CALCULATES RELEASE OF STORED ENERGY DISCHARGED DURING THE PROPAGATION OF CRACKS	
G.M.SANDQUIST ROGERS AND ASSOCIATES ENGINEERING CORPORATION				DISCUSSES METHODOLOGIES THAT MIGHT ENHANCE LOW FUSION REACTION RATES AND INCREASE THERMAL ENERGY OUTPUT

WARNING
data not verified by authors

1ST AUTHOR & INSTITUTION	METHOD	SUBJECT OF INVESTIGATION	RESULTS	COMMENTS
R.D.EAGLETON CALIFORNIA STAT POLYTECHNIC UNIVERSITY		BUSH-EAGLETON THEORY OF d-GLOBULE FORMATION	CHOOSE FIELD GRADIENTS RIGHT?	DISCUSSES AGGREGATES & GLOBULES OF D AND THE FACTORS AFFECTING FORMATION OF THESE
H.HORA UNIVERSITY OF SOUTH WALES/JUSTUS-LIEBIG-UNIVERSITY	PLASMA PHYSICS?	NON-DEGENERATE DENSE GAS OF D IN METAL		USES STATES OF ELECTRONS AND IONS IN Pd AS BASIS FOR PREDICTING METHODS FOR ENHANCEMENT OF FUSION RATES
M.H.KANG OHIO STATE UNIVERSITY	PSEUDOPOTENTIAL DENSITY FUNCTIONAL	MOLECULAR STRUCTURE OF H IN Ti		USES PSEUDOPOTENTIAL DENSITY-FUNCTIONAL TOTAL-ENERGY APPROACH TO STUDY THE EXPANSION OF H ATOMS IN Ti LATTICE. FINDS SEPARATION OF 1.6A AND 1.4A FOR TWO CASES
J.W.MINTMIRE NAVAL RESEARCH LABORATORY, WASHINGTON	"WIDE VARIETY" OF CALCULATIONS	CHEMICAL EFFECTS	NO SUGGESTION OF INTERACTION < GAS PHASE	NO ENHANCEMENT EXPECTED; CALCULATES THE INTERACTION BETWEEN DEUTERONS IN Pd FROM SEVERAL SITUATIONS AND FINDS SEPARATIONS ALWAYS LARGER THAN THE GAS PHASE
M.M.SALOMAA HELSINKI UNIERSITY OF TECHNOLOGY, FINLAND	THOMAS-FERMI	EXOTIC QUASI-ATOMS?	NO RESULTS GIVEN	ANALYZES COLD FUSION IN TERMS OF QUASI ATOMS OF DEUTERONS ORBITING A METAL ION. CRYSTAL STRUCTURE UNIMPORTANT
A.C.SWITENDICK SANDIA NATIONAL LABORATORIES	UNSPECIFIED CALCULATION	H-H SEPARATION IN Pd	ALWAYS > 2.1A	[I.E.>>.74A] H-H SEPARATION IN PdH CALCULATED AS 2.88A; H-H SEPARATION IN PdH2 CALCULATED AS 2.3A
S.-H.WEI SOLAR ENERGY RESEARCH INSTITUTE	LOCAL DENSITY FORMALISM	H2 STABILITY IN Pd	UNSTABLE	[SEPARATIONS < .74A UNLIKELY] CALCULATES ENERGY OF D-D PAIRS IN Pd FOR A VARIETY OF SITES AND FINDS NO EVIDENCE THAT ANY WILL LEAD TO COLD FUSION UNDER EQUILIBRIUM CONDITIONS
J.O'M.BOCKRIS TEXAS A&M UNIVERSITY				DISCUSSES THE ROLE OF STRESS NEAR DISLOCATIONS AS SOURCES OF CONCENTRATIONS OF D ATOMS UNDER CONDITIONS OF HIGH PRESSURE

WARNING
data not verified by authors

1ST AUTHOR & INSTITUTION	METHOD	SUBJECT OF INVESTIGATION	RESULTS	COMMENTS
Z.HUANG INSTITUTE OF LOW ENERGY NUCLEAR PHYSICS, BEIJING	SPECULATION	NON-EQUILIBRIUM d SUBLATTICE	COOPERATIVE EFFECT MIGHT CONCENTRATE ENERGY	DISCUSSES A NON-EQUILIBRIUM SUBLATTICE OF D IN Pd WHICH MIGHT FORCE ENERGY ON A FEW PAIR LEADING TO FUSION
J.KELLER UNIVERSIDAD NACIONAL AUTONOMA DE MEXICO	METHOD UNCLEAR	MOSSBAUER-LIKE EFFECTS IN d+d		ROLE OF THE LATTICE IN TAKING UP MOMENTUMS SO THAT THE d+d->4He REACTION CAN TAKE PLACE
M.GAJDA UNIVERSITY OF ARIZONA		BOSE CLUSTERS IN LATTICE DEFECTS		THE INFLUENCE OF LARGE AGGREGATES OF DEUTERONS IN LATTICE CAVITIES LEAD TO COLD FUSION; THIS OR ANOTHER DYNAMIC PHENOMENON IS REQUIRED
F.F.MUGUET TEXAS TECH UNIVERSITY	HARTREE FOCK			TRYING TO CALCULATE STABILITY OF DEUTERIUM DIMER IN PALLADIUM TETRAHEDRAL SITE
E.S.RITTNER			HEAT OF RECOMBINATION CAN EXPLAIN EXCESS HEAT	
SUBCATEGORY: CHEM & SS, NUC PHYS				
L.C.JENSEN		ANTINEUTRONS DECAY AND ANNIHILATE	MUCH CONFUSION ABOUT GAMMA RAYS	CATALYSIS OF FUSION BY ANTI-NEUTRONS
L.TURNER LOS ALAMOS NATIONAL LABORATORY		"PEREGRINATIONS"	RESONANCE EFFECTS ENHANCE PENETRATION?	SEVERAL COLD FUSION PHYSICS ISSUES DISCUSSED

WARNING
data not verified by authors

1ST AUTHOR & INSTITUTION	METHOD	SUBJECT OF INVESTIGATION	RESULTS	COMMENTS
SUBCATEGORY: CHEM & SS, PLAS EFF				
M.D.GIRARDEAU UNIVERSITY OF OREGON	PARTICLE ACCELERATION IN PLASMA OSCILLAT	PLASMA INTERACTIONS LOWER BARRIER	NO ENHANCEMENT EXPECTED	DISCUSSES "PLASMA WAKE OSCILLATIONS" AND "STIMULATED PLASMON EMISSION" WITH STATISTICAL FLUCTUATIONS AND COSMIC RAY-INDUCED MUON CATALYSIS TO EXPLAIN BURST-MODE NEUTRON EMISSION; ADDITI
SUBCATEGORY: CHEM & SS, TUN				
D.A.BAKER LOS ALAMOS NATIONAL LABORATORY	STATUS REV	SUMMARY OF METHODS TO CALC.	SUMMARY	OVERVIEW OF THEORETICAL PROBLEMS REQUIRING ATTENTION FOR ACHIEVING COLD FUSION
R.T.BUSH CALIFORNIA STATE POLYTECHNIC UNIVERSITY	D2 BOSON CONDENSATION	"SYMMETRY FORCE CATALYZATION"	RATE SHOULD BE PULSED, MAY EXPLAIN PONS ET AL	DESCRIBES "SYMMETRY FORCE CATALYZATION" AS A BASIS FOR COLD FUSION;
J.C.FISHER THOMAS PAIN ASSOCIATES	SHCK WAVE FR FUSIONS EASES INWARD SHOCK	MUON CATALYSED FUSION		CONSIDERS ENHANCEMENT OF MUON-INDUCED COLD FUSION FROM IMPLOSION OF AN ACOUSTIC WAVE GENERATED NEAR THE ENDS OF DECAY PARTICLE TRACKS;NEEDS 1.E4 FUSIONS/MUON
T.TAJIMA UNIVERSITY OF TEXAS	UNSPECIFIED CALCULATION	INTERACTION BETWEEN D'S IN Pd	40 ORDERS ENHANCEMENT IN FUSION RATE.	DESCRIBES ATTRACTIVE INTERACTION OF DEUTERONS IN A LATTICE FOR SHORT RANGES OF 0.1 TO 0.7A; EFFECT OF Pd ON D-D POTENTIAL
H.TAKAHASHI BROOKHAVEN NATIONAL LABORATORY		ELECTRON-PHONON INTERACTIONS?	[HARD TO GET LOTS OF 4He] 1.E-23/PAIR/SEC dd REQUIRES AN EFFECTIVE ELECTROM MASS OF 4-5 ELECTRON MASSES	EXPLANATION OF REQUIREMENTS FOR COLD FUSION
SUBCATEGORY: MISC				

WARNING
data not verified by authors

1ST AUTHOR & INSTITUTION	METHOD	SUBJECT OF INVESTIGATION	RESULTS	COMMENTS
P.L.HAGELSTEIN MASSACHUSETTS INSTITUTE OF TECHNOLOGY	COHERENCE?	SPECULATIVE MODEL FOR dd->4He	n AND t SUPPRESSED	[THREE BODY PROCESS DESCRIBED FOR D+D->4He+ENERGY PROCESS] AUTHOR WAS SPECULATIVE; EFFECT MAY BE SMALL
R.T.PERRY LOS ALAMOS NATIONAL LABORATORY				SOURCE STRENGTHS AND SPECTRA WITH LOS ALAMOS CODES; USEFUL FOR DESIGN OF EXPERIMENTS

SUBCATEGORY: NUC PHYS

1ST AUTHOR & INSTITUTION	METHOD	SUBJECT OF INVESTIGATION	RESULTS	COMMENTS
G.M.HALE LOS ALAMOS NATIONAL LABORATORY	R-MATRIX	REACTION RATES	INSEPARABLE RESULT, NOT A*|PSI(0)|**2 (BUT THIS MAY NOT BE BAD APPROX)	DpGAMMA IS 50-50 S+P WAVES; ddp HAS LOTS OF P WAVE TOO; 14% AT LOWEST ENERGY; ddGAMMA 4He QUINTET 5S2 E2 CAPTURE AT LOW ENERGIES; dt IS ALL S WAVE 3/2+ RESONANCE
Y.E.KIM PURDUE UNIVERSITY		CHAIN 6Li+n->t->dt->n	EXPLAINS PONS & F	[CAN'T EXPLAIN JONES (NO Li), WHERE IS dt RATE FROM?] DESCRIBES SELF-SUSTAINING CHAIN REACTION OF n+6Li->4He+T AND T+D->4He+n; CALCULATIONS NOT SHOWN; SELF-SUSTAINING CHAIN REACTIONS IN
M.RAGHEB UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN	OPPENHEIMER-PHILLIPS PROCESS	D DISINTEGRATION IN COULOMB FIELD OF "TARGET"		DESCRIBES A PROCESS OF DEUTERON DISINTEGRATION AND NEUTRON CAPTURE IN Pd
J.D.MORGAN,III HARVARD		FUSION RATES		EXCESS HEAT NOT FROM Pd->pd FUSION, ETC.

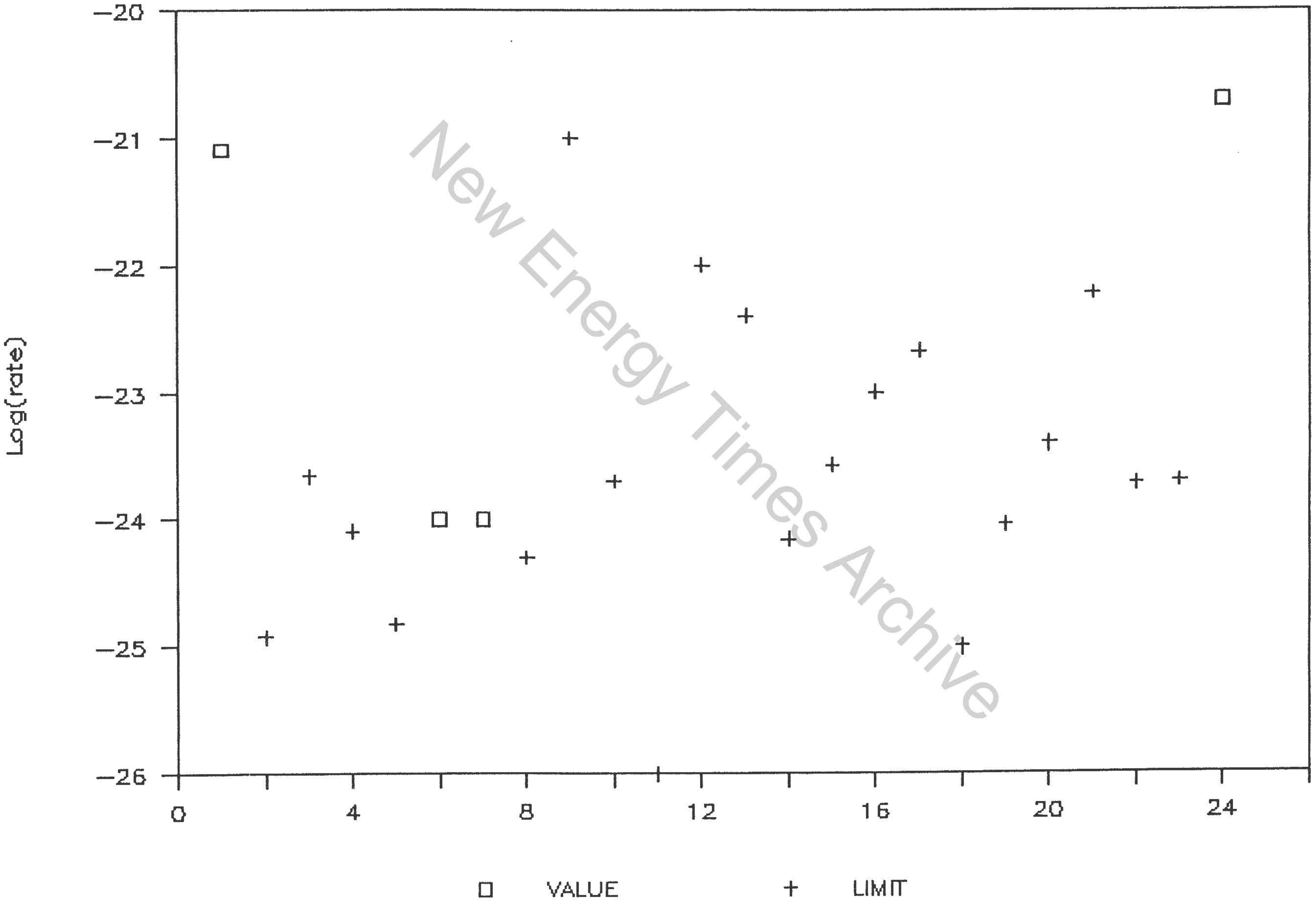
SUBCATEGORY: NUC PHYS, TUN

WARNING
data not verified by authors

1ST AUTHOR & INSTITUTION	METHOD	SUBJECT OF INVESTIGATION	RESULTS	COMMENTS
M.DANOS NIST	s-MOLECULE IN WATER FOR dd. pd 1000x	RATES:1.E-10/s-TRAP IN HYDRIDE, 1.E-22		1E-10 PER SECOND-TRAP IN HYDRIDE; 1E-22 PER SECOND-MOLECULE IN WATER; pd RATES 1.E3 FASTER THAT dd RATES; RECOIL MOMENTUM FROM LATTICE VS COULOMB PENETRATION; dd,pd RATES
SUBCATEGORY: PLAS EFF				
M.GAJDA UNIVERSITY OF ARIZONA	S(E),WKB PENETRATION FACTOR	PLASMAS IN SMALL IMPLODING POCKETS	"LARGE DENSITIES CAN BE ACHIEVED"	CROSSOVER AT RATE 1.E-24, E=200eV.TAKES RIDICULOUS SCREENING TO GIVE OBSERVED NEUTRON RATES
SUBCATEGORY: TUN				
G.S.COLLINS WASHINGTON STATE UNIVERSITY		0+ COMBINED STATE OF dd, INTERNAL CONVERSION	NO NEUTRONS OUT	DISCUSSES d+d->4He IN 0+ STATE AND DECAY BY ELECTRON CONVERSION
K.SZALEWICZ UNIVERSITY OF DELAWARE	WKB; MASSIVE ELECTRON	FUSION RATES	[RATE AS fn OF Me. HEAT UNLIKELY.] Me=4 GIVES RATE	[RESULTS NOT GIVEN IN DETAIL] DETAILED CALCULATION OF BARRIER PENETRATION WITH SUBSTANTIAL ENHANCEMENT OVER OTHER METHODS

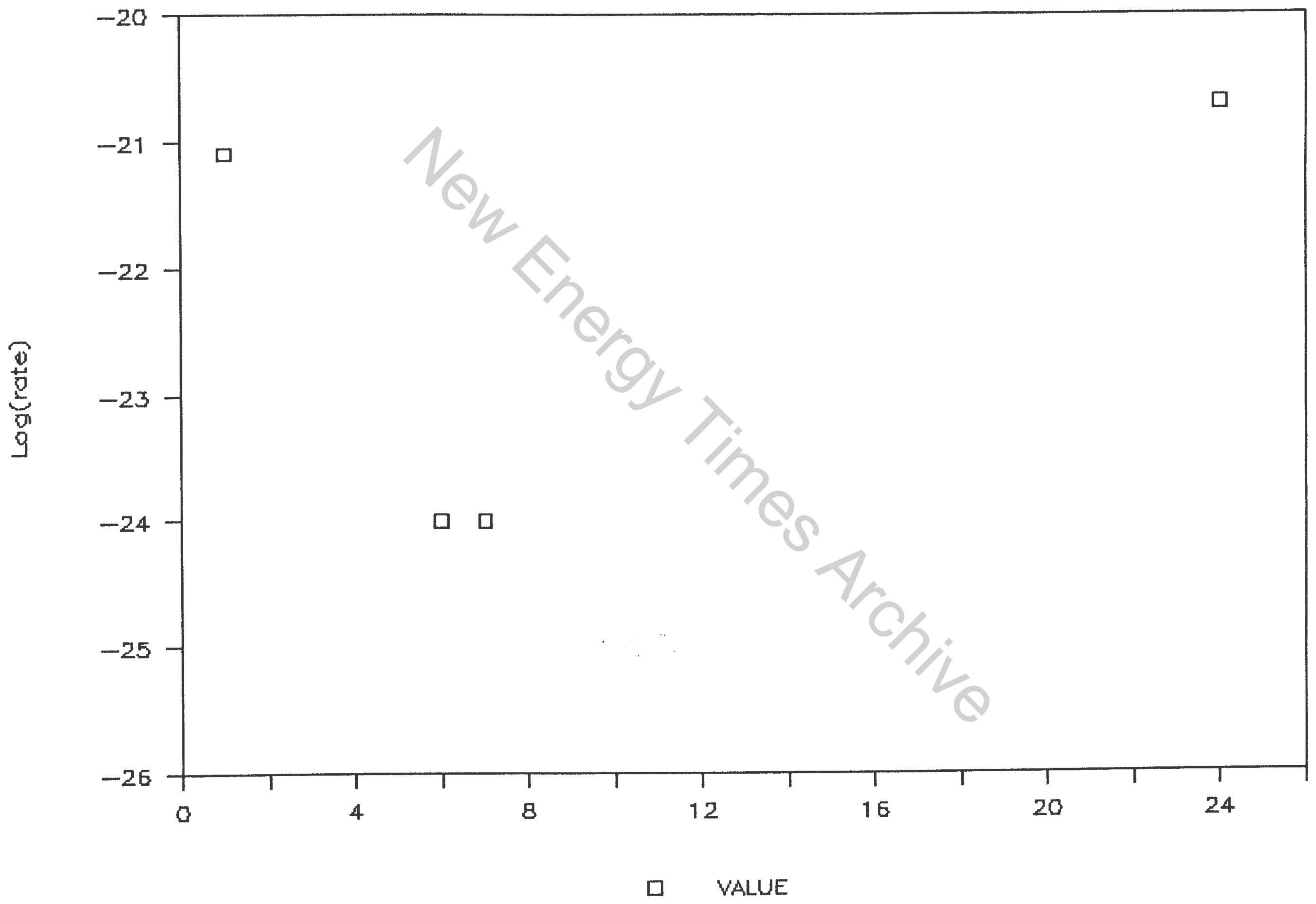
WARNING
data not verified by authors

Measured Value or Limit for Fusion Rate



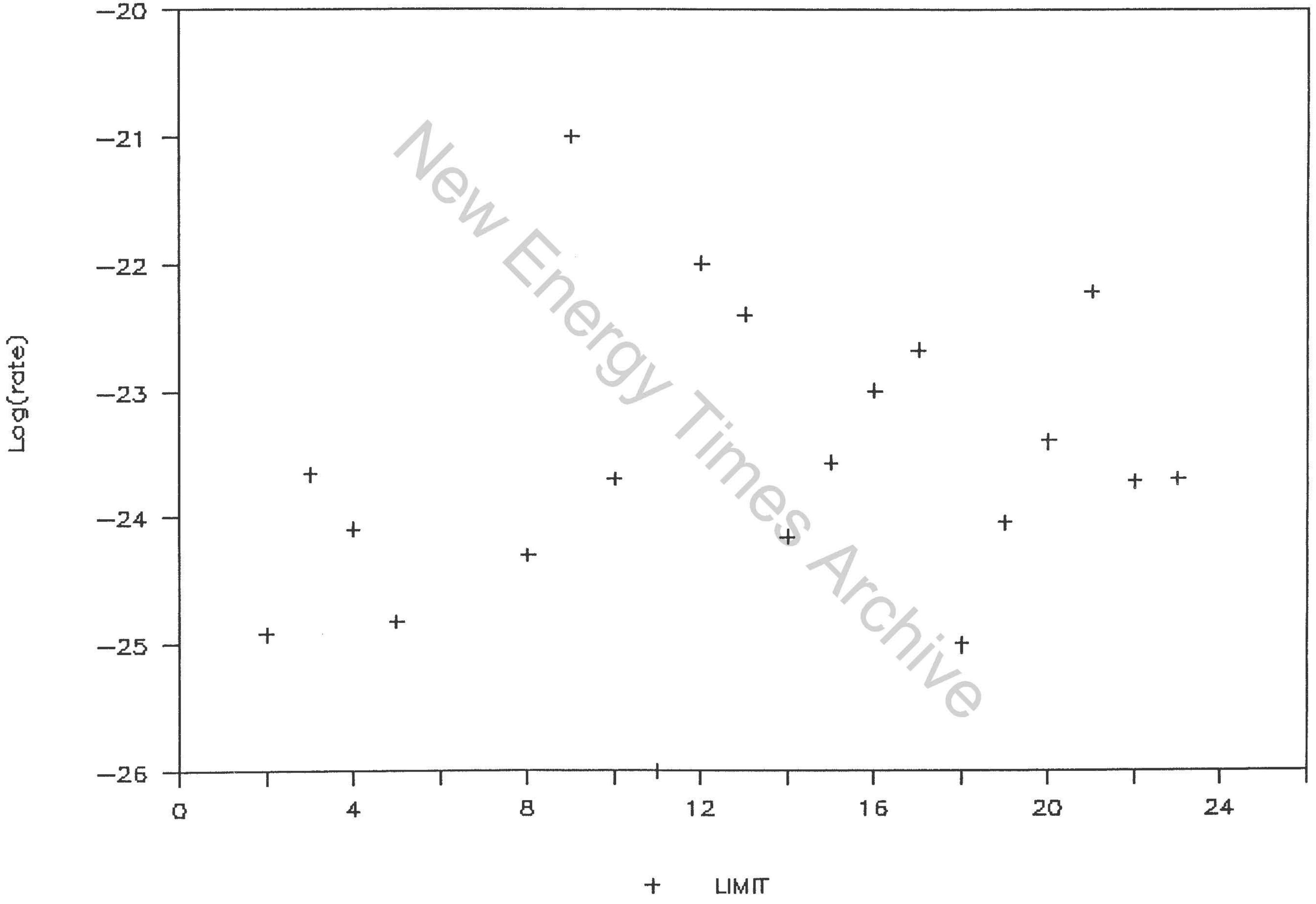
WARNING
data not verified by authors

Measured Value for Fusion Rate



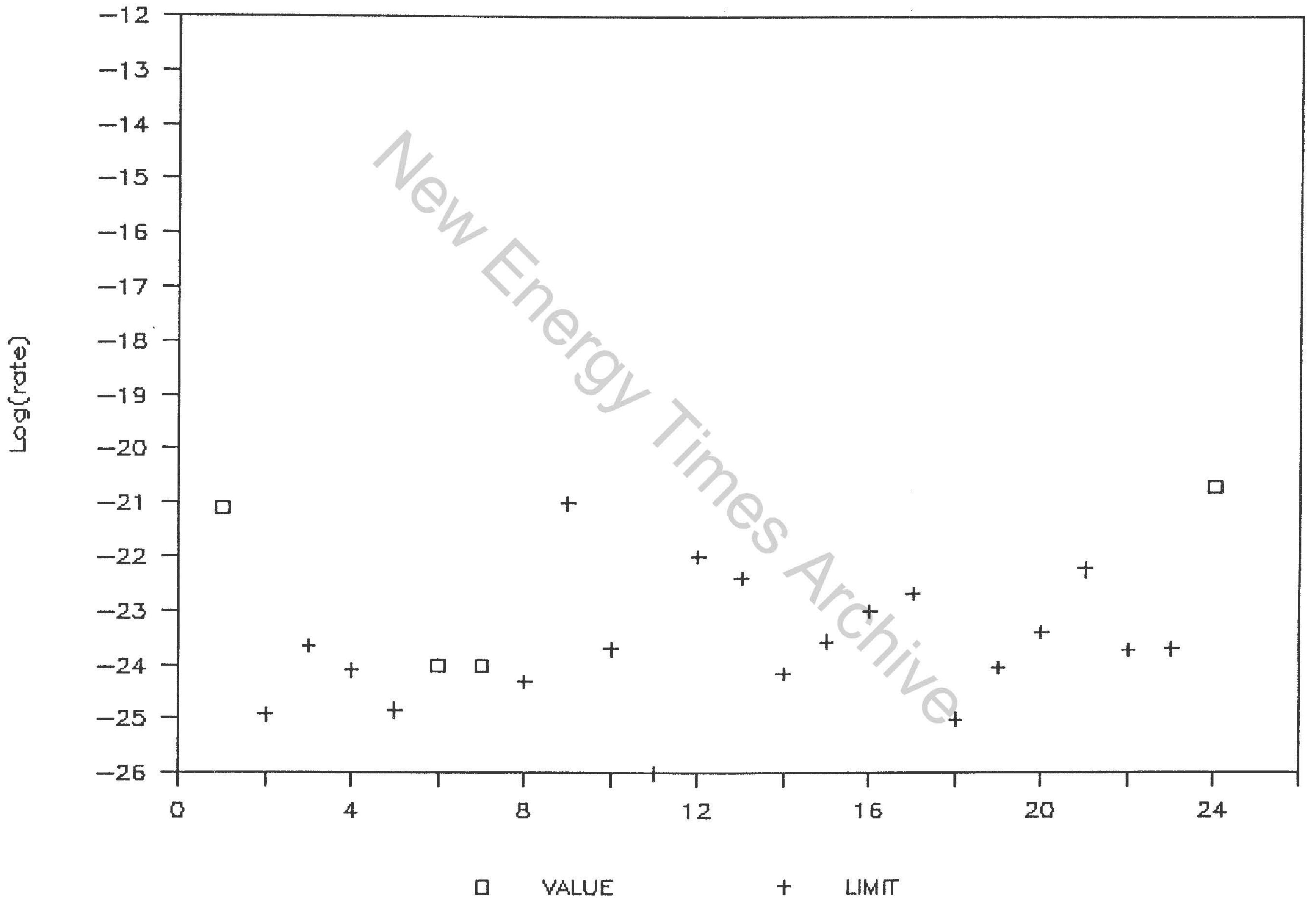
WARNING
data not verified by authors

Limit for Fusion Rate



WARNING
data not verified by authors

Measured Value or Limit Compared to PF



WARNING
data not verified by authors

Tritium in Heavy Water

Jacob Bigeleisen
Department of Chemistry
State University of New York, Stony Brook

At the Santa Fe Workshop on "Cold Fusion Phenomena" I presented a paper on the tritium content of fresh heavy water. I showed that heavy water produced by the GS process has a tritium level of 68 dpm/cc D_2O/TU. I reported that fresh heavy water currently being produced in Canada has a tritium level of 180 dpm/cc D_2O. At the meeting there was varying reports of tritium levels in heavy water and in $D_2(g)$. I have since checked up on some of these and a summary of my findings is given below:

1. Tritium produced by the GS process - 68 dpm/ml./TU.
2. Canadian D_2O 180 dpm/ml.
3. Aldrich Chemical low T D_2O <120 dpm/ml.
4. Aldrich Chemical 99.9 and 99.96 D_2O 200-300 but may be up to 5000 dpm/ml.
5. D_2O used in the ORNL experiment reported by Scott 23400 dpm/ml
6. D_2O in Texas A&M experiemnts reported by Kevin Wolf 83cpm/ml.
7. (Wolf claims to have a source of D_2O with a tritium count of 1/3 cpm/ml.!)

15 June 1989

8. At our meeting at Texas A&M on 19 June 1989 one of our committee members inquired with the Texas A&M group about the source of the 1/3 cpm/ml D_2O. They identified Isotec. I called Isotec on 21 June 1989 and spoke with their technical sales representative. These are the specifications of the D_2O that they distribute:

99.9% D Tritium < 0.1 microcurie/kg. 3.7×10^3 dps / kg → 3.7 × 60 dpm/ml.
99.96%D Tritium < 0.1 microcurie/kg.

This corresponds to 220 dpm/cc D_2O. They made a spot check about a month ago and one of their samples analyzes at 0.015 microcuries/kg. This corresponds to 33 dpm/ml D_2O. If Isotec is the supplier, then Kevin Wolf has the specific activity confused between dpm and disintegration sec^{-1}.

Thermochemistry of D_2O

Substance	ΔH°_{0f}	ΔH°_f	ΔG°_f	S°	C°_p [1]
$D_2(g)$	0	0	0	34.602	6.98
$D_2O(g)$		-59.5628	-56.0670	47.379	8.19
$D_2O(l)$		-70.4133	-58.2062	18.162	19.70
$O_2(g)$	0	0	0	49.003	7.017

---

1. All in calories (kcal.)/mol or mol/°K.
2. $N = 6.023 \times 10^{23}$ $F = 96485$ abs. coulombs 1 cal. = 4.184 abs. joules

---

ΔH to electrolyze D_2O (l) at infinite dilution of elelctrolyte

$[1.5267 - 2.00 \times 10^{-4}(t^\circ(C) - 25.00)]$ v.

1 ampere hour electrolyzes 0.373 grams (0.336 ml.) of D_2O

$H_2O = H^+ + OH^-$ $K_w = 1.01 \times 10^{-14}$

$D_2O = D^+ + OD^-$ $K_w = 1.54 \times 10^{-15}$

These have all been faxed or mailed to you. If you do not have copies, please let us know.

BIBLIOGRAPHY JUNE 22, 1989

Bailey, David C., U. Toronto, Gammas from Cold Nuclear Fusion, April 20, 1989.

Bard, et. al., Report on Salt Lake City Visit, June 2, 1989.

Bockris, J., Texas A&M, Letter to Dr. Huizenga, June 7, 1989.

Bockris, J., Texas A&M, Letter to Dr. Thompson, June 20, 1989.

Broad, William J., Fusion in a Jar, Recklessness and Brilliance, the New York Times, May 9, 1989.

Broer, Matthijs, Summary of Cold Fusion Research Activities at AT&T Bell Laboratories, June 15, 1989.

Buchanan, E., et. al., U. Rochester, Search for Neutron Production in a Palladium-Heavy Water Electrolytic Cell, April 21, 1989.

De Ninno, A., et. al., Evidence of Emission of Neutrons from a Titanium-Deuterium System

Fleischmann, M., and Pons, Stanley, Electrochemically Induced Nuclear Fusion of Deuterium.

Garwin, Richard, A Hole in the Coulomb Barrier, comments, May 9, 1989.

Garwin, Richard, Letter to John Bockris, June 13, 1989.

Garwin, Richard, Questions Provoked by Experiments, April 12, 1989.

Hagelstein, Peter, A Simple Model for Coherent DD Fusion in the Presence of a Lattice., April 10, 1989.

Hagelstein, Peter, Phonon Interactions in Coherent Fusion.

Happer, William, Comments on visit to Texas A&M, June 19, 1989.

Happer, William, Comments on visit to University of Utah, June 2, 1989.

Hayden, M.E., et al, University of British Columbia, High Precision Calorimetric.

Hudson, Richard, Pons and Fleischmann Withdraw Fusion Paper from UK Journal, Wall Street Journal, April 20, 1989.

Johnson, K.H., & Clougherty, D.P., MIT, Hydrogen-Hydrogen/Deuterium-Deuterium Bonding in Palladium and The Superconducting/Electrochemical Properties of pdH_x/PdD_x.

Jones, et. al., Observation of Cold Nuclezr Fusion in Condensed Matter, March 23, 1989.

R.C. Kainthla, et. al., Eight Chemical Explanations of the Fleischmann-Pons Effect.

R.C. Kainthla, et. al., Sporadic Observation of the Fleischmann-Pons Heat Effect.

Klyuev, V.A., et. al. High-Energy Processes Accompanying the Fracture of Solids, January 9, 1986..

Koonin, S.E. and Nauenberg, M. Cold Fusion in Isotopic Hydrogen Molecures, April 7, 1989.

Koonin, S.E., Eyewitness Report on Electrochemically Induced Cold Fusion session, May 9, 1989.

Koonin, S.E., Enhancement of Cold Fusion Rates by Fluctuations, April 19, 1989.

Langmuir, L. Pathological Science, April 1968.

Lawrence Livermore National Laboratory, Report on Cold Fusion, June 16, 1989.

Marchand, Felix, Die Naturwissenschaften, October 1926.

McCracken, D.R., et al, Atomic Energy of Canada Limited, In Search of Cold Fusion in Electrolytic Cells and Metal/Gas Systems.

Morrison, D.R.O., Cold Fusion News No. 13, 18 May, 1989

Pacific Northwest Laboratory, Summary of PNL Cold Fusion Research Activities, June 15, 1989.

Packham, et. al., Observation of Tritium Production During Electrolysis of Heavy Water Samples Using Palladium Wires.

Petrasso, et. al., X-Ray Spectra in the Fleischmann, Pons, Hawkins Experiment.

Ramsey, N., Visit to University of Utah, June 2, 1989.

Schiffer, J., Comments on Visit to Brigham Young, June 12, 1989.

Srinivasan, S., et. al., Summary of Heat Production Measuremens in the Electrolysis of D_2O, summary by J. Bigeleisen.

Walling, Cheves & Simons, Jack, U. Utah, Two Innocent Chemists Look at Cold Fusion.

Williams, David, Harwell Ends Cold Fusion Research Program, June 15, 1989.

Ziegler, J.F., et al, Electrochemical Experiments in Cold Nuclear Fusion, April 18, 1989.

COLD FUSION PANEL

JUNE 22 MEETING

ROOM 4A-110, FORRESTAL BUILDING

8:00 a.m.	Administrative Items
8:05	LANL Results
8:35	Report on Site Visits
	- Utah - Bard - Texas A&M - Miller, Biegeleisen, & TBA - CALTECH - Wrighton - BYU - Schiffer - National Laboratories - Goodwin
11:05	Update on Foreign Experiments - Huizenga
	- Harwell - Bugey
11:20	Comparison/Summary of Results - Huizenga and Ramsey
12:00	LUNCH (ROOM 6A-110)
12:45 p.m.	Discussion of Interim Report
4:50	Public Comment (10 minute rule)
5:00	ADJOURN

COLLEGE OF NATURAL SCIENCE
THE UNIVERSITY OF TEXAS AT AUSTIN

Department of Chemistry · Austin, Texas 78712-1167 · FAX (512) 471-8696

June 21, 1989

Professor Norman Ramsey
Department of Physics
Harvard University
Cambridge, MA 02138

Professor John Huizenga
Department of Chemistry
University of Rochester
Rochester, NY 14627

Dear Norm and John:

I thought that John Bockris' letter, which questions the qualifications of the electrochemistry members of the cold fusion panel, deserved a formal response. Bockris implies that Bard, Miller, and Wrighton have no background in "physical electrochemistry" (at least as Bockris defines it) and so are not qualified to evaluate the electrochemical component of the work performed in connection with "cold fusion". First, allow me to point out that all three of these individuals served as physical electrochemistry editors for the Journal of the Electrochemical Society. Miller continues in this role and is also the chairman of the physical electrochemistry division of the Society. Moreover, all of us have published numerous papers in fields that would be considered within the realm of physical electrochemistry, e.g., studies of semiconductor/liquid interface and rotating ring disk electrode studies of electrode kinetics. Another member of the committee, who, strangely, was not mentioned in Bockris' letter, is Larry Faulkner. Larry was chairman of the physical electrochemistry division several years ago and has served as the American associate editor of the Journal of Electroanalytical Chemistry. Larry is the current vice president of the Electrochemical Society and will assume the presidency next year.

Perhaps Bockris would prefer people with his own special brand of physical electrochemistry, which is more closely related to electrochemical technology, e.g., fuel cells and hydrogen economy, than those who come out of a fundamental chemistry background. However, since the technological implications of "cold fusion" do not seem to be a major issue at this time, I don't see that such people would greatly add to the needed competency and expertise of the panel.

Sincerely,

Al

Allen J. Bard
Hackerman/Welch Regents Chair

bt

Summary of cold fusion research activities at AT&T Bell Laboratories, Murray Hill, NJ
(June 15, 1989)

The research effort in cold fusion at AT&T Bell Labs was started almost immediately following the announcement by Pons and Fleischman on March 23, 1989. Since then a relatively small number of researchers carried out a variety of experiments aimed primarily at verifying the effects claimed both by P&F and Jones et al. This entailed the following topics:

1. Raghavan, Broer, Feldman, et al concentrated on the detection of neutrons emitted by a possible dd –> n reaction in electrochemically deuterated palladium rods. A NaI(Tl) scintillation detector with an efficiency of 0.015 was employed. Rod dimensions, electrolyte solution, and current densities were similar to those used by P&F. After approx. 30 days of counting no significant neutron levels were observed and an upper limit was established for the fusion rate: $<2.2\times10^{-24}$ (ddn) fusions/dd–pair.sec. This is five orders of magnitude lower than that claimed by P&F and about a factor of 5 lower than the original Jones claim. These results were reported at the APS meeting, May 1, 1989 and at the Santa Fe meeting on Cold Fusion Phenomena, May 23–25, 1989. A detailed report will be published in the proceedings of the latter meeting. This experiment has been discontinued.

2. Fleming, Law, et al focussed on electrochemical calorimetry of Pd–D systems. The calorimetric responses of Pd/Pt and Pt/Pt electrode combinations in 0.1 M LiOD and 0.1 M LiOH electrolytic solutions have been investigated. The calorimeter used is a Seteram HT–1000, a high precision instrument directly measuring the absolute heat flux from a single or a pair of balanced 15 cm^3 cells. Experiments have been performed in both open cells and sealed cells. The case of open cell calorimetry shows clearly that it is very difficult to assess the calorimetric response because some mechanisms for energy loss are unspecified and can also vary as a function of many experimental parameters. On the other hand, the sealed cell experiments, performed with an in–situ recombination catalyst are unambiguous. These have been performed on Pd cathode material prepared in several ways. The heat input and ouput balance within 2%. This work is continuing.

3. Vyas and Hanson performed experiments which monitor changes of electric potential at a palladium cathode in a conventional electrolysis cell over long periods in an effort to develop a potential sensor of the hydrogen content of a palladium electrode. Excursions in the potential have been observed which can be associated with phase transitions in the hydrogen/palladium system. This work is being continued.

Matthijs M. Broer
AT&T Bell Laboratories
Murray Hill, NJ 07974

Faxed to Panel
5/16/89

AT&T

AT&T Bell Laboratories

600 Mountain Avenue
Murray Hill, NJ 07974-2070
201 582-3000

June 15,1989

Professor J. Huizenga
co-chairman,
Energy Research Advisory Board Cold Fusion Panel
Dept. of Chemistry
Univ. of Rochester
Rochester, NY 14627

Dear Professor Huizenga:

Please find attached a short summary of the recent activities on cold nuclear fusion research at AT&T Bell Laboratories, as we discussed during our brief conversation in Santa Fe last month.

As you can see the activity has been rather small and recently has been scaled back significantly in view of the large number of negative results, both in the calorimetric as well as the nuclear radiation aspects of these phenomena.

Please feel free to contact me if I can be of any further assistance to your committee in determining the merits of and future directions for cold fusion.

Sincerely Yours,

Matthijs M. Broer

encl.

Tel. (201) 582-7761

cc.: G.Y. Chin - AT&T Bell Laboratories
C.K.N. Patel
K.L. Walker

06/23/89

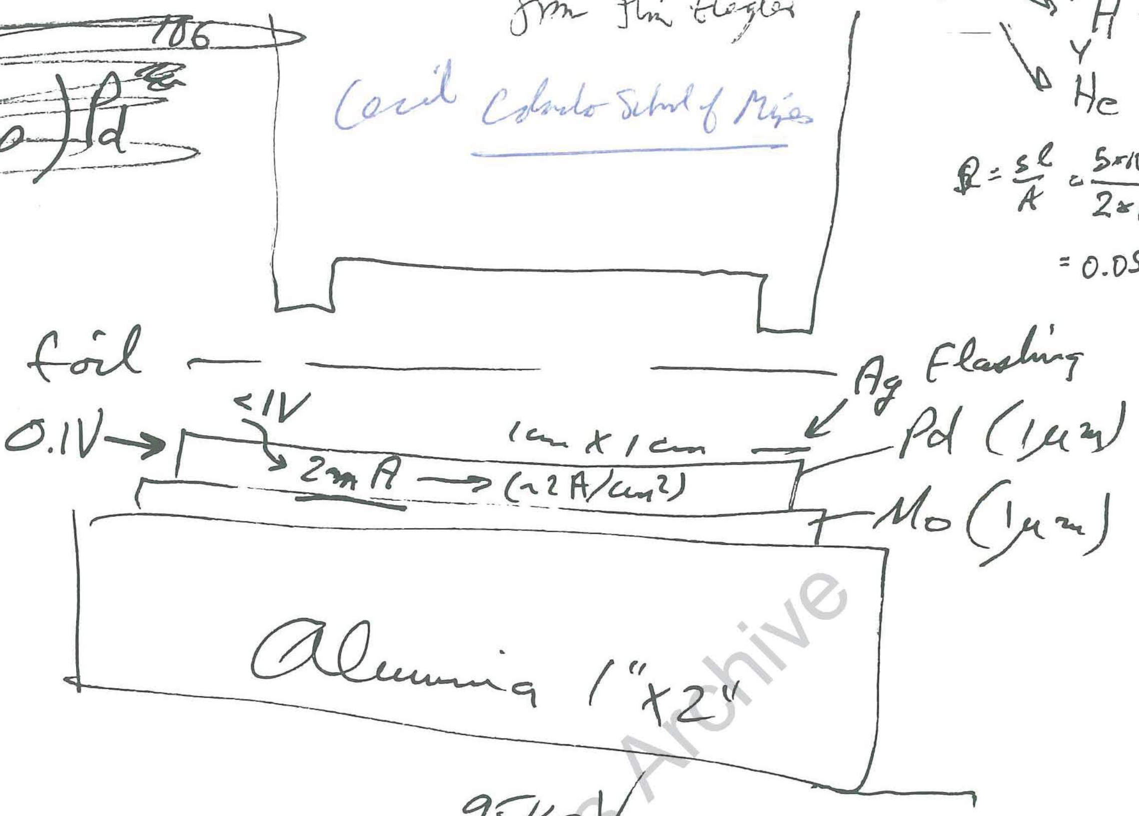
from Jim Ziegler

Cecil Colorado School of Mines

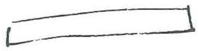
~~$^{105}Pd(d,p)^{106}Pd$~~

$$d+d \rightarrow \begin{cases} {}^{3}He + n \\ {}^{3}H + p \\ \gamma\ {}^{4}He\ (.01\%) \end{cases}$$

$$R = \frac{\rho l}{A} = \frac{5\times10^{-6}\times 2}{2\times10^{-4}} = 0.05\ \Omega$$



$5\times10^{6}\ A/cm^{2}$



$10^{-4}/cm^{2}$

95KeV

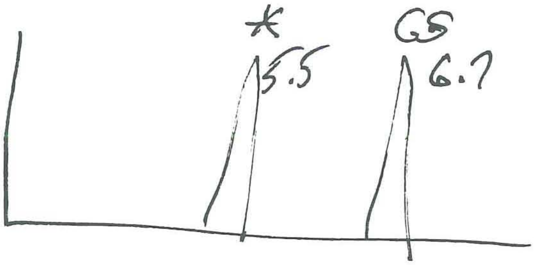
① Implant D (~$2\times10^{19}/cm^{2}$) (~10% D in Pd)

② Put SBD over Sample

③ Turn on DC Current (Long)
~1-2 Amps/cm²

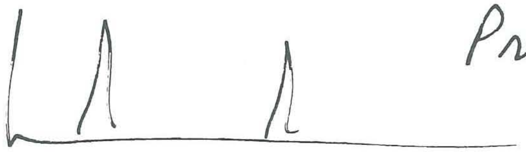
p: 70/day

④ Lasts about a month



Gets 2 peaks

⑤ Puts Foil Shield



Protons!

⑥ Turn off Current

THE
UNIVERSITY
OF UTAH

2020A Henry Eyring Building
Telephone: 801-581-6689
FAX: 801-581-8433

June 28, 1989

Prof.Steven Koonin
Kellogg Radiation Laboratory
California Institute of Technology
Pasadena, CA 91125

Dear Professor Koonin:

At the meeting of the Electrochemical Society in Los Angeles, there were several offers made to do an analysis of rods used in the Fleischmann-Pons experiment for the appearance of ^{4}He. In fact, the assertion was made that there would be many laboratories interested in assisting us in this way. We would like to follow up on this offer, and it is for that purpose that I am writing to you.

Our plan is to run a double blind experiment inviting about five laboratories to participate. We have asked Dr. John Morrey of the Pacific Northwest Laboratory, operated by Battelle Memorial Institute for the Department of Energy to act as mediator. Early in July, and before July 22, we shall send to Dr. Morrey several 2 mm x 10 cm rods of palladium, all taken from the same original lot, some of which have performed successfully in the Pons-Fleischmann laboratory, and some of which serve as controls. These shall be identified only by letter. These rods will be segmented in Dr. Morrey's laboratory, and then distributed to the participating laboratories, which then will search for the presence of ^{4}He according to their procedures. It is our hope that this work will be completed before the end of August, at which time we shall meet with Dr. Morrey in order to provide the full identification of the individual rods, and to obtain the data. At that time we shall make a preliminary analysis of the data, and plans for further collaboration.

Continued on Page 2...

Department of Chemistry
Henry Eyring Building
Salt Lake City, Utah 84112

I hope that you will be willing to participate with us in this project. In any case, you should direct your response to Dr. Morrey (address below) who shall be making the selection of the participators and shall provide further information on the proposed analysis:

Dr. John Morrey
Pacific Northwest Laboratories
Battelle Memorial Institute
P. O. Box 999
Richland, WA 99352

Telephone: 509-376-3777
FAX: 509-376-3876

Sincerely,

Hugo Rossi

Hugo Rossi, Interim Director
Cold Fusion Research Project

HR:cjs

cc: John Morrey
Martin Fleischmann
B. Stanley Pons

P.S. A second copy of this letter was mailed to you in care of:
GA Technologies
10955 John H. Hopkins Drive
Building 29
San Diego, CA 92038